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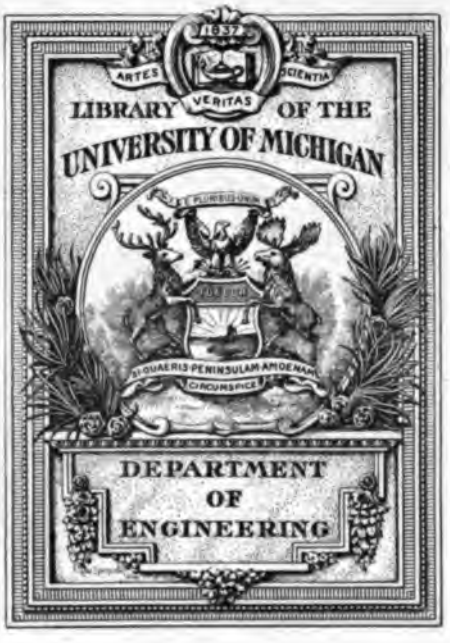
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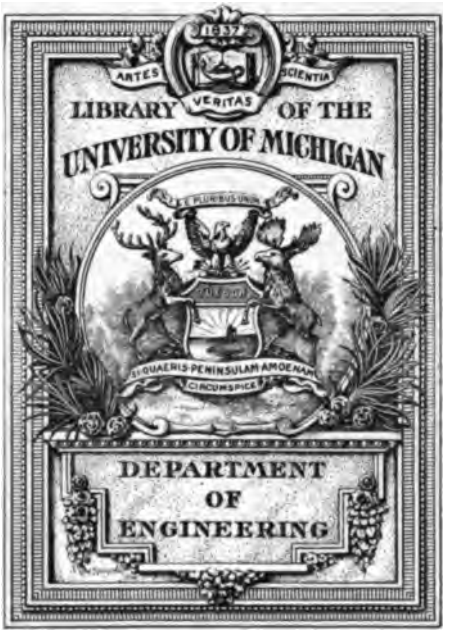
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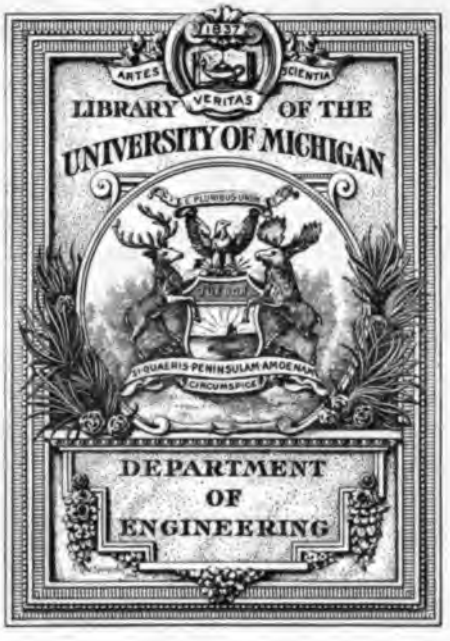
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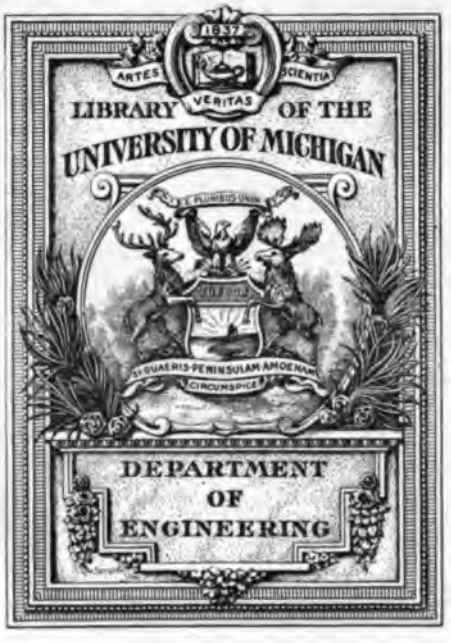
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VOLUME XII.

TWELFTH SESSION, 1895-96.

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ERRATA.

On page 7, *omit* the 12th and 13th lines from foot of page enclosed in brackets, in 1st award.

On page 37, last line but one, *for* "Howell torpedo," *read* "Brennan torpedo."

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GERMAN LLOYD'S REGISTER OF SHIPPING, 1896.

HULL INSTITUTION OF ENGINEERS AND NAVAL ARCHITECTS, *Vol.* IX., 1893-94.—Boiler Furnaces: Their Construction and Renewal. Incrustation in Steam Boilers. The Subdivision and Pumping Arrangements of the First-class Cruisers Recently Constructed. Boiler Management and Inspection. Notes on the Past Twenty Years of Hull Steam Shipping. Some Recent Developments in Marine Engineering.

IRON AND STEEL INSTITUTE, *No.* 1, 1895.—On Metal Mixers. The Effect of Arsenic on Steel. The Mines of Elba. The Manufacture of Steel Projectiles in Russia. Ternary Alloys of Iron. *No.* 2.—The Iron Industry of South Staffordshire. On the Mineral Resources of South Staffordshire. On the Direct Puddling of Iron. Ironworks of South Russia. The Thermo-chemistry of Bessemer process. The production of Iron by a new process. A new process for the Analysis of Chrome Ore and Ferro-chromium. Nickel Steel and its Advantages over Ordinary Steel. Small Cast Steel Ingots. Cooling Curves and Tests for Cast Iron. Hardening of

Steel. 1896, *No.* 1.—On the Ford and Moncur Hot Blast Stove. The Production of Metallic Bars of any Section by Extrusion at High Temperatures. On the Treatment of New Zealand Magnetic Iron-sands. On the Making of the Middle Lias Ironstone of the Midlands. The Introduction of Standard Methods of Analysis. On the Rate of Diffusion in Iron. Mond Produce—Gas Applied to the Manufacture of Steel. Further Notes on the Hardening of Steel. A Study of some Alloys with Iron Carbides, mainly Manganese and Tungsten.

JUNIOR ENGINEERING SOCIETY, *Vol.* IV., 1893-4.—Boiler Incrustations and Deposits. Boilers for Locomotive Engines. Devon and Cornwall, Industries of. Electro-motors. Gas Manufacturing Coal. Lubricants. Marine Engine Repairs. The Altitude of the Sun. *Vol.* V., 1894-5.—The Study of Alloys. Locomotive Repairing Work. Marine Engine Design of To-day. Alternating Current Motors. Warming Buildings by Hot Water. Water-works and their Appliances.

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LLOYD'S REGISTER OF BRITISH AND FOREIGN SHIPPING, 1896.

INGENIEURS CIVILS DE FRANCE, Année 49, *Parts* III., V., and VI., 1896.—Nouveau tracedes lignes d'influence des moment dans une partre continu de sedin constante. Applications de Statique Grapho-algebrique. L'or et de diament au Transvaal et au Cap. Explosions de une Charleroi. A foyer interieur amovible a Joinville le peut Mechanique des Systemès Materials. Extension Possible de differents bassins houillers de la France. Les Locomotives Electriques Systeme. La Machines a ecrire Application du Pneumatique aux Vehiculs a Chevaux et sans Chevaux.

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Hydraulic Stoking Machinery and Labour Saving Appliances in Modern Gas Works. Notes on Hydraulic Power Supply in Towns. Recent Engineering Improvements of the Clyde Navigation. Notes on Modern Steel Works Machinery.

MARINE ENGINEERS, 1894-95, *Vol.* VI.—Mechanical Appliances for the Shipment of Coal. Damage Surveys. The Commercial Speed of Steamships (J. D. Young). Raising Wrecks and Sunken Vessels.

INSTITUTION OF NAVAL ARCHITECTS, *Vol.* XXXIV., 1895.—Harbour and Docks of Southampton. The Importance of Fuel in very fast Vessels, and on the Advantage to be derived from Heating the Feed Water. Influence of Circulation on Evaporative Efficiency of Water-tube Boilers. Design of Mail Steamers. Rapid Method of Calculating Wetted Surfaces. Recent experience with Cylindrical Boilers and the Ellis and Eaves Suction Draught. Ventilation of Steamships.

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Engineering, 35 and 36, Bedford Street, Strand, London, W.C.
Engineers' Gazette, Prudential Buildings, Mosley Street, Newcastle-upon-Tyne.
Fairplay, 34, Leadenhall Street, London, E.C.
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Indian Engineering, Pat. Doyle, Esq., C.E., Star Press, 19, Lall Bazar, Calcutta. British India.
Industries and Iron, 39 and 40, Shoe Lane, London, E.C.
Journal de la Marine le Yacht, 55, Rue de Châteaudun, Paris.
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NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

List of Members, July, 1896.

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(A.)	Agent and Accountant.	(I. & S. M.)	Iron and Steel Merchants and Manufacturers.
(B. B.)	Boiler Builder.	(M.)	Merchant.
(C. E.)	Civil and Consulting Engineer.	(M. S.)	Marine Superintendent.
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The Right Hon. Lord Armstrong, C.B., D.C.L., F.R.S., Cragside, Rothbury		Nov. 1884
The Right Honourable the Earl of Ravensworth, Ravensworth Castle, near Gateshead-on-Tyne...		Nov. 1884
Sir W. H. White, K.C.B., LL.D., F.R.S., The Admiralty, Whitehall, London	(N A)	Nov. 1884

MEMBERS.

A.

Abey, Henry, Fairfield, York Road, West Hartlepool	(E)	Jan. 1889
Adamson, Alex., c/o Messrs. Naval Construction and Armaments Co., Barrow-in-Furness	(S)	Nov. 1885
Adamson, Cumberland, 3, Close Street, Sunderland	(S)	Nov. 1893
Adamson, Daniel, c/o Messrs. Joseph Adamson & Co., Hyde, Cheshire	(E) Graduate,	Feb. 1888
	(E) Member,	Oct. 1894
Aisbitt, Matthew Wheldon, 47, Mount Stuart Square, Cardiff ...	(N A)	Oct. 1895
Alder, Sydney, Edinbro' Buildings, South Shields	(C E & N A)	Nov. 1893
Allan, Jas. McNeal, 3, Parkville, Heaton, Newcastle-on-Tyne ...	(E)	Dec. 1886
Allardes, Wm., c/o Messrs. Harland & Wolff, Ltd., Engine Works, Belfast	(E)	Nov. 1884
Anderson, Joseph, c/o Messrs. Wigham Richardson & Co., Neptune Works, Walker-on-Tyne	(E)	Nov. 1884
Andrew, D., 33, Osborne Road, Jesmond, Newcastle-on-Tyne ...	(SUR)	Jan. 1885

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Andrews, Jas., Drawing Office, Royal Shipbuilding and Engineering Works, Flushing, Holland ... ... (E) Nov. 1884
Angus, W. J., Messrs. Naval Construction and Armaments Co., Barrow-in-Furnace ... ... (E) Oct. 1892
Anthony, Jas., Messrs. Cleland's Graving Dock and Slipway Co., Willington Quay-on-Tyne ... ... (S) Oct. 1886
Archbold, Joseph G., c/o Messrs. Blyth Dry Dock Co., Blyth ... (E) Jan. 1889
Archbold, William, c/o Messrs. Ernest Scott, Mountain, & Co., The Close, Newcastle-on-Tyne ... ... (E) Mar. 1894
Armour, Jas. Glencairn, Bureau Veritas, Custom House Court, Quayside, Newcastle-on-Tyne ... ...(SUR) Oct. 1895
Armstrong, Joseph, 96, Roker Avenue, Sunderland... ... ... (S) Nov. 1892
Armstrong, Robert B., Victoria Terrace, Whitley, near Newcastle-on-Tyne ... ... (E) Oct. 1887
Armstrong, R. W., Dunston Engine Works, near Gateshead-on-Tyne (E) Oct. 1895
Armstrong. William S., c/o Chilian Naval Construction, Valparaiso ... ... (S) { Graduate, Oct. 1892; Member, April 1895
Arnison, Geo., Jun., 61, Fawcett Street, Sunderland (N A & SUR) Nov. 1884
Atherton, William Henry, 47, Lovaine Place, Newcastle-on-Tyne (E) Oct. 1891
Atkinson, F. C., 37, Croydon Road, Newcastle-on-Tyne ... ... (E) Dec. 1892
Atkinson, John Joseph, 7, Swiss Road, Elm Park, Fairfield, Liverpool ... ... (E) Mar. 1891
Austin, W. R., Lloyd's Register of Shipping, Royal Exchange, Middlesbrough ... ... (E SUR) Oct. 1888
Ayre, James Reay, Roman Wall, Wallsend-on-Tyne ... ... (S) Jan. 1894

B.

Bagnall, T. W., The Groves, Winlaton-on-Tyne ... ...(F M) Nov. 1893
Baguley, Ernest Edwin, Lyndhurst, Rowley Park, Stafford ... (E) April 1891
Bailey, Charles H., Tyne Engine Works, Newport ... ... (E) Mar. 1896
Bailey, James, 3, South Avenue, Ryton-on-Tyne ... ... (E) Nov. 1884
Baines, Geo. Henry, Messrs. Central Marine Engineering Co., West Hartlepool ... ... (E) Oct. 1888
Baird, George, 22, Lovaine Place, North Shields ... ... (E) Oct. 1892
Baird, Robert, 13, Hylton Terrace, North Shields ... ... (E) Jan. 1890
Barclay, James, Lloyd's Register of Shipping, Swansea ... ...(SUR) Nov. 1888
Barley, C. J., c/o Messrs. The Kensington and Knightsbridge Electric Lighting Co., Chapel Place, Brompton Road, London, S.W. ... ... (E) { Graduate, Feb. 1885; Member, Dec. 1886
Barnett, James Rennie, Lilybank House, Johnston, N.B.... ... (S) Oct. 1889
Barnsley, John, Field House West, North Shields ... ... (E) May 1892
Barrett, A., Staith House, West Hartlepool ... ... (E) May 1896
Barron, T. G., Hobourne, Elwick Road, West Hartlepool... ... (E) Oct. 1888
Barrow, A. R., Holly Grove, Littleworth, near Pulbrough, Sussex (E) Feb. 1891
Batey, John Thomas, 25, Harrison Place, Newcastle-on-Tyne ... (S) Nov. 1885
Batliboi, Jehangir Framji, 71, Apollo Street, Fort, Bombay ... (E) Dec. 1888
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Bell, William, West Wing, Point Pleasant, Wallsend-on-Tyne ... (E) Nov. 1888

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Bell, William, 45, Broughan Street, Greenock	(S)	April 1893
Bergström, Gus., Bergsund, Stockholm	(N A)	Mar. 1886
Berkley, A. B., Kent Villas, Jarrow-on-Tyne	(E)	Mar. 1887
Bewlay, Charles J., 5, Warrington Road, Newcastle-on-Tyne ...	(S)	Nov. 1895
Bigge, D. L. Selby, 27, Mosley Street, Newcastle-on-Tyne... ...	(E E)	Nov. 1894
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Black, J., c/o Messrs. J. Merryweather & Co., West Hartlepool ...	(E)	Nov. 1888
Black, Wm., Messrs. Black, Hawthorn, & Co., Gateshead-on-Tyne	(E)	Jan. 1885
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Blackie, Thomas Reid, Lloyd's Register of Shipping, 2, White Lion Court, Cornhill, London	(SUR)	Nov. 1890
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Blumer, Wm., 2, Ashmore Terrace, Stockton Road, Sunderland ...	(S)	Dec. 1886
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Bodin, Lauritz M., 27, Argyle Square, Sunderland... ...	(E & SUR)	Dec. 1889
Bone, W. J., 61, Linskill Terrace, North Shields	(S)	Dec. 1884
Bonnyman, James Smith, 64, Plasturton Avenue, Cardiff... ...	(E)	Nov. 1889
Boolds, Jas. H., c/o Messrs. Sir Raylton Dixon & Co., Cleveland Shipyard, Middlesbrough	(S)	Oct. 1886
Booth, Edward Spence, c/o C. Furness, Esq., 85, Water Street, Boston, U.S. America	(E)	Oct. 1889
Booth, John William, Union Foundry, Rodley, near Leeds ...	(E)	April 1892
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Boyd, Arthur, 5, Windermere Street, Gateshead-on-Tyne ...	(E SUR)	May 1895
Boyd, Wm., North House, Long Benton, Newcastle-on-Tyne ...	(E)	Nov. 1884
Boyt, John T., Messrs. Earn Line Steamship Co., Girard Building, Philadelphia, Pa., U.S.A....	(E)	Nov. 1893
Bramwell, Balfour, c/o Messrs. Harland & Wolff, Engine Works, Belfast	(E)	Graduate, Nov. 1886 Member, Nov. 1887
Brankston, R. T., 36, Hawthorn Street, Newcastle-on-Tyne ...	(E)	Nov. 1884
Bredsdorff, Thomas, Messrs. The Flensburg Shipbuilding Co., Flensburg, Germany	(S)	Oct. 1894
Brew, George, 85, Water Street, Boston, U.S. America	(SUR & C E)	May 1896
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Broadbent, Frank, c/o Messrs. J. H. Holmes & Co., Portland Road, Newcastle-on-Tyne	(E E)	Nov. 1893
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Brown, James, c/o Sociedad Anonima, de los Astilleros del Nervion, Bilbao, Spain	(E)	Mar. 1891
Brown, Robson, 1, Belle Vue Terrace, Tyne Dock	(E)	Nov. 1889
Brown, T. R., 27, Ripon Street, Sunderland	(E)	Graduate, May 1885 Member, Oct. 1886
Brown, William, c/o Messrs. Siemens Brothers & Co., Woolwich...	(E)	April 1887
Browne, Sir B. C., Westacres, Benwell, near Newcastle-on-Tyne	(C E)	Jan. 1885
Buchanan, A., Michaelson Villa, Barrow-in-Furness	(S)	Nov. 1884
Buchanan, John H., Oswald Chambers, 5, Oswald Street, Glasgow	(SUR)	Oct. 1888
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ELECTED.

Bulmer, Frederick Charles, 2, Graingerville North, Newcastle-on-Tyne ... ... (E) { Graduate, May 1894; Member, Oct. 1895
Bulmer, John, 1, Graingerville North, Newcastle-on-Tyne ... (E) Mar. 1886
Bulmer, John George, 34, Brighton Grove, Newcastle-on-Tyne ... (E) May 1894
Burnett, Norman, Watergate Buildings, Newcastle-on-Tyne ... (E) Oct. 1891
Bushell, Chas. A., 1, Benton Terrace, Newcastle-on-Tyne (N A & SUR) Nov. 1893
Butterfield, George, 4, Kayall Road, Sunderland ... ... Nov. 1884

C.

Calvert, Geo. A., Wellington Villa, St. Luke's, Cork ... ... (E) Nov. 1893
Cama, Nusserwanji Bomanji, Sleaton Road, Tardeo, Bombay, British India ... ... (E) Dec. 1888
Cameron, Angus, c/o James Laing, Esq., Deptford Yard, Sunderland (S) Nov. 1892
Cameron, David, 11, Graham Place, Dundee ... ... (E) April 1891
Campbell, J. Jennings, Bureau Veritas Register of Shipping, 155, Fenchurch Street, London, E.C. ... ... (E) Oct. 1888
Campbell, John M., 4, Winchester Terrace, Newcastle-on-Tyne ... (N A) April 1895
Campbell, Thomas, c/o Messrs. Hills Dry Dock Co., Cardiff ... (S) Mar. 1894
Camps, H. E. J., Ivy Bank, Bede Burn Road, Jarrow-on-Tyne ... (N A) Oct. 1894
Cannell, Frank, Messrs. H. Parry & Son, Lisbon ... ... (E & S) Nov. 1887
Carruthers, Frank, 9, Battlefield Gardens, Langside, Glasgow ... (E) Nov. 1893
Carstons, Samuel, Messrs. Burmeister & Wains, Maskin-og Skibsbyggeri, Copenhagen, Denmark... ... ... (S) Dec. 1887
Casey, James, 10, Philpot Lane, London, E.C. ... ... (E) Nov. 1891
Cay, Arthur, Messrs. Cay, Hall, & Co., Quayside, Newcastle-on-Tyne... ... ... (E) Nov. 1884
Ceuvel, John L., Kantoor, Gebouw, Amsterdam ... ... (E) Mar. 1886
Chandler, Noel, Messrs. Bumsted & Chandler, Cannock Chase Engine Works, Hednesford, Staffordshire ... ... (E) Oct. 1891
Chapman, Harry Reynolds, Messrs. Clarke, Chapman, & Co., Gateshead-on-Tyne ... ... (E) Mar. 1893
Chapman, Hedley, 147, Park Road, Newcastle-on-Tyne ... ... (E) Feb. 1886
Charlton, Henry, 1, Millfield Terrace, Gateshead-on-Tyne ... (E) Nov. 1884
Charlton, R. B., Jun., Manors Railway Station Works, Newcastle-on-Tyne ... ... (E) Nov. 1884
Charlton, T., 25, Lincoln Street, Gateshead-on-Tyne ... ... (E) Nov. 1884
Charlton, Thomas, The Cedars, Millhill, West Cowes, Isle of Wight (E) Nov. 1890
Chaston, Edward Catmore, 45, Cardigan Terrace, Heaton, Newcastle-on-Tyne ... ... (E) Oct. 1894
Cherry, Thos. Wm. Fry, c/o Messrs. R. & W. Hawthorn, Leslie, & Co., St. Peter's, Newcastle-on-Tyne ... ... (E) Oct. 1894
Chicken, Thomas, c/o Messrs. Newport Engineering and Ship Repairing Co., Newport, Monmouth ... ... (E) Oct. 1892
Chisholm, Alexander, 2, Sea View Terrace, Fulwell, Sunderland... (S) Mar. 1893
Christie, C. J. D., Neptune Works, Walker-on-Tyne ... ... (S) Nov. 1884
Christie, J. D., 4, Colbeck Terrace, Tynemouth ... ... (S) Nov. 1884
Churchill, James Dixon, 9, London Street, London, E.C.... ... (E) Oct. 1889
Clague, James Henry, Birkenhead Iron Works, Birkenhead ... ... (S) { Graduate, April 1891; Member, May 1894
Clark, Geo., Southwick Engine Works, Sunderland ... ... (E) Nov. 1884
Clark, George, Jun., Southwick Engine Works, Sunderland ... (E) Feb. 1888

ELECTED.

Clark, Henry, Southwick Engine Works, Sunderland ... ... (E) Oct. 1887
Clark, James Carver, 2, Albert Terrace, West Hartlepool ... ... (E) Nov. 1892
Clarke, Henry Trevisa, Deptford Shipyard, Deptford, Sunderland (S) Mar. 1892
Cohn, William M., 2, Marine Terrace, North Shields ... ... (S) Nov. 1893
Coleby, James W., Carlyle Street, Willington Quay-on-Tyne ... ... (E) { Graduate, Oct. 1891; Member, Jan. 1894 }
Coletti, Silvio, 83, Park Road, Newcastle-on-Tyne ... ... (S) Dec. 1895
Common, John B. A., 51, Mount Stuart Square, Docks, Cardiff ... (E) April 1896
Conning, Alfred C., Dunston Iron & Steel Works, Gateshead-on-Tyne (F M) May 1885
Conràdi, Carl, 8, Toldbodgaden, Christiana, Norway ... ... (E) Nov. 1884
Consiglio, Luigi, 8, Via Paterno, Palermo ... ... (N A) Nov. 1890
Cooper, Nusserwanji Naoroji, Indo-China Mills, Dader, Sivri, Bombay, India ... ... (E) Oct. 1889
Cooper, Sidney, 14, Northgate, Hartlepool ... ... (E) { Graduate, Nov. 1891; Member, May 1895 }
Cooper, W., Jun., 11, Ridley Place, Newcastle-on-Tyne (E) { Graduate, Nov. 1890; Member, Jan. 1894 }
Coote, Arthur, Messrs. R. & W. Hawthorn, Leslie, & Co., Hebburn-on-Tyne ... ... (S) Nov. 1884
Copeman, William C. J., 10, Brinkburn Terrace, South Shields ... (E) Oct. 1892
Cornish, H. P., Lloyd's Register of Shipping, Hull ... ... (E) Oct. 1888
Couche, Henry Drew, c/o Messrs. Laird Bros., Birkenhead ... (S) Oct. 1891
Courtier-Dutton, W. T., British Corporation Registry of Shipping, 69, St. Vincent Street, Glasgow... ... ... (S SUR) April 1890
Cowens, William Edward, c/o Messrs. John Abbot & Co., Gateshead-on-Tyne ... ... (E) Dec. 1889
Craggs, Ernest H., Messrs. R. Craggs & Sons, Middlesbrough ... (S) Oct. 1888
Craig, John C., Lloyd's Register of Shipping, 3, St. Nicholas' Buildings, Newcastle-on-Tyne ... ... (E SUR) Oct. 1890
Craig, Robert, Pageland House, Grange Road, West Hartlepool ... (E) Nov. 1892
Crawford, Jas., Bureau Veritas Register of Shipping, 9, Custom House Court, Quayside, Newcastle-on-Tyne ... ... (S SUR) Nov. 1886
Crawford, W. A. F., Westminster Chambers, 9, Victoria Street, London, S.W. ... ... (E) Nov. 1884
Crofton, Charles, 17, Albany Terrace, Whitley, near Newcastle-on-Tyne... ... ... (E) Nov. 1995
Crookston, John, 72, Mark Lane, London, S.E. ... ... (E) Mar. 1896
Cross, Wm., 24, Windsor Terrace, Newcastle-on-Tyne ... ... (E) Mar. 1886
Cruddas, W. D., M.P., Messrs. Sir W. G. Armstrong, Mitchell, & Co., Elswick, Newcastle-on-Tyne ... ... (E) Dec. 1884
Cruickshank, Alexander, Albany Buildings, 47, Victoria Street, London, S.W. ... ...(SUR) Mar. 1892
Cumming, Alexander, 20, Lorne Terrace, Sunderland ... ... (E) Nov. 1891
Cumming, William, c/o James Laing, Esq., Deptford Shipyard, Sunderland... ... ... (E) Mar. 1896
Cummins, W. R., Violet Bank, Wormit, Fife... ... ... (E) Nov. 1884

D.

Dadd, Edward Martin, c/o Messrs. The Oriental Steamship Co., 84, Leadenhall Street, London, E.C. ... ... (E) Mar. 1892
Dalrymple, Wm., Myrtle Cottage, W. Cleadon, Sunderland ... (E) Dec. 1886

ELECTED.

Dalrymple, William, Jun., 14, Vicarage Terrace, Sunderland ... (E) Dec. 1895
Daniel, Alfred John, Surveyor's Office, Board of Trade, North Shields ... ... (S) Nov. 1893
Darling, W. J., Lloyd's Register of Shipping, Dock Chambers, Barry ... ... (S) April 1887
Darney, John, c/o Messrs. Short Bros., Pallion, Sunderland ... (S) Nov. 1884
Davis, Thos. Wilfrid, Birkenfeld, Bromley, Kent ... (E) { Graduate, Jan. 1891 / Member, Mar. 1894
Denny, Archibald, c/o Messrs. W. Denny & Bros., Dumbarton ... (S) Dec. 1891
De Rusett, Edwin W., Warden House, Percy Park Road, Tynemouth ... ... (S) Nov. 1890
Dick, Francis, 6, Gladstone Street, Sunderland ... ... (E) Nov. 1885
Dick, F. W., c/o Messrs. Palmer's Shipbuilding Co., Jarrow-on-Tyne... ... ... (I & S M) Oct. 1891
Dickie, James, 428, Mississippi Street, Poturo, San Francisco, California, U.S.A.... ... ... (S) Mar. 1894
Dickinson, F. T., 23, Park Place W., Sunderland ... (E) { Graduate, May 1885 / Member, Oct. 1886
Dickinson, James, The Cloisters, Sunderland ... ... (E) Nov. 1884
Dickinson, John, Park House, Sunderland ... ... (E) Nov. 1884
Dickinson, W., Park House, Sunderland ... ... (E) Nov. 1884
Dietze, F. G., Messrs. The Hamburg South American Steam Ship Company, Hamburg ... ... (E) Nov. 1893
Dixon-Brown, L. D., 42, Burdon Terrace, Newcastle-on-Tyne ... (S) Nov. 1886
Dixon, James, Welbeck Road, Walker-on-Tyne ... ... (S) Dec. 1893
Dixon, John Rochester, 79, Osborne Road, Newcastle-on-Tyne ... ... (E) { Graduate, Oct. 1887 / Member, Feb. 1893
Dixon, Sir Raylton, Cleveland Shipyard, Middlesbrough... ... (S) Feb. 1888
Dixon, William, Heaton Hall Road, Heaton, Newcastle-on-Tyne... (E) Nov. 1893
Dobson, William, Shipbuilder, Walker-on-Tyne ... ... (S) Nov. 1888
Donald, George Gray, 2, South Preston, North Shields ... ... (E) Oct. 1890
Donald, James, 2, Chatsworth Street, Sunderland ... ... (S) Nov. 1884
Donkin, George, St. Andrew's Engine Works, Newcastle-on-Tyne (E) Oct. 1892
Donovan, J. W., 5, Ash Place, Newcastle Road, Sunderland ... (E) April 1885
Dos Santos, Apolinaris J., Rio Grande-do-Sul, Brazil ... (SUR) Nov. 1891
Douglas, John F., c/o Messrs. Ramage & Ferguson, Leith... ... (E) Jan. 1888
Douglass, William, Globe Iron Works, Winlaton-on-Tyne... ... (E) Nov. 1893
Downing, Nicholas, Oxford Terrace, Norton Road, Stockton-on-Tees ... ... (I F) Oct. 1894
Dowsen, Chas., 21, Croft Terrace, Jarrow-on-Tyne... ... ... (E) Dec. 1885
Doxford, Albert Ernest, B.A., 2, West Lawn, Sunderland (E) { Graduate, Oct. 1890 / Member, Nov. 1893
Doxford, Charles D., Bainbridge Holme, Tunstall Road, Sunderland (S) Nov. 1884
Doxford, Robert P., Pallion Engine Works, Sunderland ... ... (E) Nov. 1884
Doxford, W. Theodore, M.P., Pallion Shipyard, Sunderland ... (S) Nov. 1884
Drake, William Edward, 7, Rodwell Terrace, Weymouth ... ... (E) Feb. 1893
Drakenberg, J., 73, Nybrogatan, Stockholm, Sweden ... ... (E) Feb. 1886
Duckitt, Jno., 4, St. Nicholas' Buildings West, Newcastle-on-Tyne (E) Nov. 1884
Duckitt, John Brentnall, 19, Whitehall Terrace, Sunderland... ... ... (E E) { Graduate, Oct. 1888 / Member, April 1895
Dudgeon, F. S., 30, Great St. Helens, London, E.C. ... ... (E) Feb. 1885
Dugdale, William H., Green Bank, Jarrow-on-Tyne ... ... (S) Mar. 1894

ELECTED.

Duguid, Robert, c/o Messrs. Harland & Wolff, Drawing Office Department, Belfast ... ... (S) Oct. 1892
Duncan, George Thos., c/o Messrs. Tangyes Limited, 3, St. Nicholas' Buildings, Newcastle-on-Tyne ... ... (E) Nov. 1894
Dunlop, William, 6, Chatsworth Terrace, Barrow-in-Furness ... (E) Mar. 1888
Dyer, Charles M. B., Lloyd's Register of Shipping, 3, St. Nicholas' Buildings, Newcastle-on-Tyne ... ... (E SUR) Oct. 1892
Dykes, George, Lloyd's Register of Shipping, Steinhoeft 3, Hamburg ... ... (S) Jan. 1893
Dykes, James, 82, Park Road, Newcastle-on-Tyne ... ... (E) May 1885
Dykes, John, Lloyd's Register of Shipping, Oriel Chambers, Liverpool ... ...(SUR) Oct. 1889

E.

Edmiston, Jas. B., Ivy Cottage, Highfield Road, Walton, Liverpool (E) Nov. 1886
Edwards, James Harry, Jun., High Docks, South Shields ... ... (S) Mar. 1893
Eeles, Robert, Queen Street, Newcastle-on-Tyne ... ... (E) April 1889
Egan, James, 72, Riviera House, Collingwood Road, West Hartlepool ... ... (E) Dec. 1893
Elder, Edward, c/o Messrs. J. & G. Thomson, Clydebank, Glasgow ... ... (S) { Graduate, Nov. 1890; Member, Oct. 1892 }
Elliot, Henry ... ... (E) May 1891
Elliott, William D., Hessle, Hull ... ... (E) Nov. 1894
Ellis, Robert Elwood, Messrs. Cumming & Ellis, Inverkeithing, Fife ... ... (S) Feb. 1891
Eltringham, Joseph T., Stone Quay, South Shields... ... (S & B B) Oct. 1889
English, Thos. (Lieut.-Col.), Hawley, near Dartford, Kent ... (E) Oct. 1890
Erdtman, Herman, c/o Mr. W. Lindberg's Varf, Stockholm, Sweden ... ... (E) Nov. 1893
Eshelby, William, 13, Brankingham Terrace, Norton Road, Stockton-on-Tees ... ... (E) Feb. 1888
Evans, Charles, c/o Messrs. The Vulcan Shipbuilding and Engineering Co., Stettin, Germany ... ... (E) Mar. 1891
Evans, Lewis, c/o Ralph Carr, Esq., Maritime Buildings, King Street, Newcastle-on-Tyne ... ...(SUR) Dec. 1890
Evans, William, Superintendent Engineer, Caerphilly, near Cardiff (E) Nov. 1889
Evans, William T., c/o Messrs. John Cory & Sons, Mount Stuart Square, Cardiff ... ... (E) Mar. 1896
Ewen, Alex., 22, Albany Terrace, Whitley, near Newcastle-on-Tyne ... ... (E) { Graduate, Oct. 1891; Member, Jan. 1894 }

F.

Fairbairn, James, 54, Amberly Street, Sunderland... (E) { Graduate, May 1885; Member, April 1895 }
Farina, A. J., 63, Quayside, Newcastle-on-Tyne ... ... (E) Nov. 1884
Farrar, Harrie Crawhall, 18, Gladstone Street, Hartlepool ... (S) Nov. 1893
Faruffini, Capt. M. C., c/o Connitato Pei Designa delle Navi Ministero dilla Marina, Rome, Italy ... ... (N A) Dec. 1888
Feldtmann, H., Surveyor to Bureau Veritas, Bergen, Norway ... (E) Jan. 1889

ELECTED.

Fenwick, James, B.Sc., C.E., 19, Bridge Street, Sydney, New South Wales ... ... (E) Oct. 1892
Ferrier, Robert M., B.Sc., Durham College of Science, Barras Bridge, Newcastle-on-Tyne ... ... (E) Nov. 1892
Filley, George Frederick, 5, Park Terrace, Govan, Glasgow ... (S) Nov. 1891
Finch, Herbert K., Colliery Agent, c/o Messrs. Blainscough Colliery Co., Coppull, near Chorley, Lancashire (E) { Graduate, Dec. 1888; Member, Nov. 1894 }
Findlay, John Taylor, 14, Nelson Street, Sunderland ... ...(SUR) Feb. 1890
Fish, Thomas Wilson, Lloyd's Register of Shipping, Calcutta, British India ... ...(SUR) May 1892
Fisher, John, 16, Belle Vue Park, Sunderland ... ... (S) April 1895
Fleming, Charles Edward, 71, Elswick Road, Newcastle-on-Tyne (E) Nov. 1884
Fletcher, Robert, Walker Forge, Walker-on-Tyne ... ... (F M) Dec. 1886
Flohr, Justus, Elisabethstrasse 10, Stettin, Germany ... ... (E) Oct. 1886
Foley, Wm. C. le B., Box 537, Newport News, Virginia, U.S.A. ... ... (S) { Graduate, Nov. 1887; Member, Oct. 1892 }
Ford, David, c/o Messrs. J. Boyd & Co., Shanghai, China ... ... (E) May 1891
Forster, Alfred Lindsay, Shaftesbury Place, Gateshead (E) { Graduate, Nov. 1891; Member, Oct. 1895 }
Forster, William, c/o Messrs. Dixon, Robson, & Co., 2, Collingwood Street, Newcastle-on-Tyne ... ... (E) Mar. 1890
Foster, Henry, c/o Messrs. Galloway & Co., Knott Mills Ironworks, Manchester ... ... (E) April 1885
Fothergill, J. R., Dock Office, West Hartlepool ... ... (C E) Mar. 1886
Fowell, Ridley, Lloyd's Register of Shipping, Dock Office, West Hartlepool ... ...(S & E SUR) Feb. 1893
Fowling, Charles, Lloyd's Register of Shipping, Dock Office Buildings, West Hartlepool ... ... (S) Nov. 1892
Fownes, Henry, Tyne Forge, Ouseburn, Newcastle-on-Tyne ... (F M) Nov. 1884
Fox, Samson, Messrs. The Leeds Forge Co., Leeds (*Life Member*) (E) Dec. 1887
Fox, William, 9, Winfield Terrace, Chester Road, Manchester ... (E) April 1895
Franki, J. P., c/o Messrs. Morts Dry Dock and Engineering Co., Sydney, N.S.W., Australia ... ... (E) Jan. 1886
Fraser, Thomas S., Messrs. Ernest Scott, Mountain & Co., The Close, Newcastle-on-Tyne ... ... (E E) Jan. 1894
Freeman, Alfred Isaac ... ... (E) { Graduate, Dec. 1890; Member, Nov. 1893 }
Furneaux, J. B., Victoria Engine Works, Gateshead-on-Tyne ... (E) Nov. 1885
Furse, Fred., Villa Schlaepfer, Capodimonte, Naples ... ... (S) April 1887

G.

Gad, Oscar, Deptford Shipyard, Deptford, Sunderland ... ... (S) Nov. 1893
Gaine, Roger L., 43, Harrison Street, Barrow-in-Furness (E) { Graduate, Dec. 1887; Member, Oct. 1894 }
Gannaway, H. G., 11, Kent Street, Jarrow-on-Tyne ... ... (S) Nov. 1884
Garthwaite, John R., c/o Messrs. R. Ropner & Sons, Stockton-on-Tees (S) May 1889
Gayner, Robt. H., Jun., Beech Holm, Sunderland ... (E) { Graduate, Mar. 1886; Member, Oct. 1888 }
Gearing, Ernest George, Penshurst, Clarence Drive, Harrogate ... (E) Dec. 1892
Geddes, Christopher, 2A, Drury Lane, Water Street, Liverpool ... (E) Oct. 1888

ELECTED.

Gibson, David, 18, Wadsworth Avenue, Cardiff ... ... (E) June 1896
Gibson, H., 162, Roker Avenue, Monkwearmouth, Sunderland ... (S) Nov. 1884
Gibson, J. Hamilton, 171, Upper Brook Street, Manchester (E) { Graduate, April 1891 / Member, Oct. 1894
Gibson, W. H., 37, Tatham Street, Sunderland ... ... (E) Nov. 1884
Good, Farraut, c/o Messrs. Bute Dry Dock Co., Ltd., Roath Basin, Cardiff ... ... (E) Mar. 1896
Gordon, William James, c/o Messrs. Naval Construction and Armaments Co., Barrow-in-Furness ... ... (E) Oct. 1887
Gordon, William Leslie, Invermark, Broughty Ferry, N.B. ... (E) April 1893
Graham, Edwin, Messrs. Osbourne, Graham, & Co., Hylton, Sunderland ... ... (S) Nov. 1884
Graham, William, Ford Lodge, South Hylton, near Sunderland ... (S) Nov. 1884
Graham, William, West House, Tynemouth ... ... (S) Oct. 1891
Graham, William, 30, Hill Street, Jarrow-on-Tyne ... ... (S) April 1893
Graham, William, Primrose Villa, Kingsland Crescent, Barry Docks, South Wales ... ... (E) Nov. 1894
Gravell, John, Bureau Veritas Register of Shipping, Custom House Court, Quayside, Newcastle-on-Tyne ... ... (N A SUR) Nov. 1884
Gray, A., 17, Belgrave Terrace, Newcastle-on-Tyne ... ... (E) Nov. 1888
Gray, George, 6, Salem Hill South, Sunderland ... ... (E) Feb. 1888
Gray, Harry, 19, St. George's Terrace, Jesmond, Newcastle-on-Tyne... ... ... (E) Dec. 1885
Gray, Sir William, Messrs. W. Gray & Co., West Hartlepool (S & E) Oct. 1888
Green, Frederick W., 14, Monk Street, Sunderland... ... ... (E) Nov. 1894
Green, W. G., Engine Department, Messrs. Palmer's Iron and Shipbuilding Co., Jarrow-on-Tyne ... ... (E) Nov. 1884
Green, William, c/o Messrs. Naval Construction and Armaments Co., Barrow-in-Furness ... ... (E) Oct. 1885
Greenhow, John, 9, Rowell Street, Hartlepool ... ... (S) Oct. 1894
Greig, David William, Messrs. Inman's Shipyard, Limited, Lymington, Hants ... ... (E) Mar. 1891
Grimes, Thomas Benjamin, 45, Eastbourne Grove, South Shields... (E) Mar. 1890
Gross, Felix, Assistant Manager, c/o Messrs. John Brown & Co., Atlas Works, Sheffield ... ... (I & S M) Feb. 1893
Gulston, A., Clayton Park Lodge, Jesmond, Newcastle-on-Tyne ... (E) Dec. 1888
Gunn, John, Managing Director, Messrs. Mount Stuart Dry Docks Co., Cardiff (*Life Member*) ... ... June 1896

H.

Hake, G. A., 29, Rothbury Terrace, Heaton, Newcastle-on-Tyne...(SUR) Oct. 1888
Hall, Edward, 68, Grange Road West, Jarrow-on-Tyne ... ... (S) Nov. 1885
Hall, J. Percy, Carville, Laurie Park Road, Sydenham, London, S.E. (E) Oct. 1885
Hall, John W., c/o Messrs. John Scott & Co., Abden Works, Kinghorn, N.B. ... ... (S) Oct. 1887
Halley, David, Messrs. Burmeister & Wains, Maskin-og Skibsbyggeri, Copenhagen, Denmark (*Life Member*) ... ... (E) Feb. 1887
Hamilton, Robert C., Messrs. Stabilimento Armstrong, Pozzuoli, Naples, Italy ... ... (E) { Graduate, Dec. 1892 / Member, Oct. 1895
Hamilton, R. R., c/o Messrs. Maudslay, Sons, & Field, Westminster Bridge Road, Lambeth, London ... ... (E) Nov. 1884

ELECTED.

Hammar, Hugo G., Bureau of Construction and Repairs, U.S. Navy Yard, Brooklyn, New York, U.S.A. ... ... (S) Nov. 1890
Harding, J. C., Fernville Terrace, West Hartlepool... ... ... (E) Nov. 1884
Harkness, Richard, Grange Road, West Hartlepool ... (S SUR) Nov. 1884
Harlow, F., 8, Benton Terrace, Newcastle-on-Tyne ... ... (E) Nov. 1884
Harman, Bruce, Messrs. The Linde British Refrigerating Co., 35, Queen Victoria Street, London, E.C. ... ... (E) Oct. 1886
Harold, F., 140, Cardigan Terrace, Heaton, Newcastle-on-Tyne ... (E) Nov. 1888
Harper, J. H., 1, Beaumont Street, North Shields ... ... (E) Jan. 1885
Harris, Anthony, c/o Messrs. Copley, Taylor, & Co., Engineers, Middlesbrough ... ... (E) Mar. 1892
Harrison, Alfred, Scotia Engine Works, Sunderland ... ... (E) Oct. 1889
Harrold, Alexander, 26, Park Road, Newcastle-on-Tyne ... ... (E) Nov. 1884
Harrold, F., 140 Cardigan Terrace, Heaton, Newcastle-on-Tyne ... (E) Nov. 1888
Harroway, George Mitchell, Philiphaugh, Wallsend-on-Tyne ... (S) Jan. 1896
Harvey, John W. J., 1, Richmond Villa, Chertsey Road, Redland, Bristol ... ... (E) Feb. 1889
Havelock, Michael, G, Exchange Buildings, King Street, Newcastle-on-Tyne ... ... (E) Dec. 1887
Head, Archibald P., 47, Victoria Street, London, S.W. (E) { Graduate, Nov. 1884 / Member, Oct. 1887 }
Headlam, Robert, New Park Terrace, Hartburn Lane, Stockton-on-Tees ... ... (E) Nov. 1886
Heck, John H., Lloyd's Register of Shipping, 3 St. Nicholas' Buildings, Newcastle-on-Tyne ... ... (S SUR) Nov. 1885
Henderson, Alex., c/o Messrs. Empreza, Nacional, De. Nav. D'Vapor, Lisbon ... ... (E) April 1893
Henderson, A. M., 3, Greatham Terrace, West Hartlepool ... (E) Nov. 1890
Henderson, George, 54, Westmorland Road, Newcastle-on-Tyne... (E) Nov. 1884
Henderson, John, 34, Burdett Street, Liverpool ... ... (N A) June 1896
Henshall, Samuel, c/o Messrs. Sir Raylton Dixon & Co., Cleveland Shipyard, Middlesbrough ... ... (S) { Graduate, May 1885 / Member, Jan. 1894 }
Hepburn, Alfred, Northumberland Forge, Wallsend-on-Tyne ... (F M) Dec. 1890
Hepple, William, Slipway, South Shields ... ... (E & S) Oct. 1885
Hepple, William Thos., Messrs. Hepple & Co., Engineers, Wapping Street, South Shields ... ... (E) Dec. 1893
Hesketh, Thomas, Bryn Tirion, Richmond Road, Cardiff ... ...(SUR) April 1896
Hildrey, A. J., 28, Rosslyn Terrace, Sunderland ... ... (S) Nov. 1884
Hill, Maxwell, 2, The Side, Newcastle-on-Tyne ... ... (N A) Nov. 1884
Hindson, William Forster, 19, Ravensworth Terrace, Gateshead-on-Tyne ... ... (E) { Graduate, Nov. 1891 / Member, Nov. 1892 }
Hirst, Richard, Lloyd's Register of Shipping, Dock Offices, West Hartlepool ... ... (E SUR) Nov. 1885
Hodge, Rowland F. W., Messrs. C. S. Swan & Hunter, Wallsend-on-Tyne ... ... (S) Dec. 1890
Hogg, James, 8, Lovaine Terrace, North Shields ... ... (B F) Nov. 1889
Hök, Wilhelm, Deptford Shipyard, Sunderland ... ... (S) Oct. 1886
Holbrook, Thomas, 22, St. Hilda Street, Hartlepool ... ... (E) Nov. 1893
Holgate, Charles H., Cardigan Villa, Grove Lane, Headingley, Leeds ... ... (E) Feb. 1895
Hollis, Henry William, Whitworth House, Spennymoor ... ... (I M) Oct. 1891
Holmes, John H., Portland Road, Newcastle-on-Tyne ... ... (E E) Jan. 1888

ELECTED.

Homji, A. C. N., 13, Trinity Street, Dhobie, Talao, Bombay, India (E) Nov. 1884
Hooper, Ernest, 27, Whitehall Terrace, Sunderland ... ... (E) Nov. 1885
Hopkinson, Frank A., c/o Messrs. J. Hopkinson & Co., Huddersfield (E) Dec. 1891
Houston, John, 32, Randolph Street, Sunderland ... ... (E) Nov. 1894
Humble, Stephen, Jun., c/o Messrs. Anti-Attrition Metal Co., Ltd., Emerson Street, Southwark, London, S.E. ... ... (E) Feb. 1896
Hunter, George B., Messrs. C. S. Swan, Hunter, & Co., Wallsend-on-Tyne ... ... (S) Nov. 1884
Hunter, J. W., 10, Princess Road, Stockton Road, Sunderland ... (E) May 1885
Hunter, Summers, c/o Messrs. N.E. Marine Engineering Co., Northumberland Engine Works, Wallsend-on-Tyne ... ... (E) Nov. 1885
Hutchinson, C. W., 6, Park Parade, Westmorland Road, Newcastle-on-Tyne ... ... (E) Nov. 1884
Hutchinson, Wesley, B.A., 6, Park Parade, Newcastle-on-Tyne ... (E) Oct. 1891
Hutchison, J., Board of Trade Offices, Middlesbrough ... ...(SUR) Dec. 1891
Hutchison, Thomas Allan, 98, Warwick Street, Heaton, Newcastle-on-Tyne ... ... (S) Nov. 1891

I.

Inglis, John, c/o Messrs. Hawthorn & Co., Leith ... ... (S) April 1887
Inglis, John, Pointhouse Shipyard, Partick, Glasgow ... (E & S) Oct. 1886
Inman, Douglas S., 17, Wandsworth Road, Heaton, Newcastle-on-Tyne ... ... (E) Oct. 1892
Irwin, J. H., Sunderland Engine Works, South Docks, Sunderland (E) Nov. 1884
Irwin, Thomas F., 1, St. Alban's Road, Bootle, near Liverpool ... ...(C E & N A) Mar. 1888

J.

Jack, William C., Service Subventionné des Correspondances Fluviales au Tonkin, Haiphong, China ... ... (E) Nov. 1894
Jackson, A., Surveyor's Office, Board of Trade, North Shields (E SUR) Nov. 1888
Jackson, Albert S., c/o Messrs. The Baron Hambro' Steamship Co., Ltd., Mount Stuart Square, Cardiff ... ... (E) Mar. 1896
Jackson, Herbert Stonewall, c/o Messrs. Westgarth, English, & Co., Middlesbrough ... ... (E) Dec. 1891
Jackson, William S., Messrs. Gourlay Bros. & Co., Camperdown Shipyard, Dundee... ... ... (S) April 1891
James, M. C., 18, Denmark Street, Gateshead-on-Tyne ... ... (S) Nov. 1884
Jeffrey, Philip, 98, Park Road, Newcastle-on-Tyne... ... ... (E) Dec. 1892
Jobling, J. C., Blackwall Ironworks, Isle of Dogs, London, E. ... (E) Nov. 1884
Jobling, W. J., 1, Akenside Hill, Newcastle-on-Tyne ... (E & S O) Nov. 1884
Jobson, H. G., Exchange Buildings, West Hartlepool ... ...(SUR) June 1896
Johnson, Alexander, 9, Cheltenham Terrace, Heaton, Newcastle-on-Tyne ... ... (E) Feb. 1893
Johnson, Johan, 7, Vestra Hamngaten, Gothenburg, Sweden ... (S) May 1885
Johnson, T. Allan, Dry Docks, Passage West, Cork ... ... (S) Nov. 1884
Johnstone, William, Lloyd's Register of Shipping, Barrow-in-Furness ... ...(SUR) Nov. 1884
Joicey, Jacob G., Forth Banks West Factory, Newcastle-on-Tyne (E) Jan. 1889

ELECTED.

Jones, Charles, 10, Glyurhondda Street, Cardiff ... ... (E) Mar. 1896
Jones, George, c/o Messrs. W. Gray & Co., West Hartlepool ... (S) Oct. 1888
Jones, Morlais G., 6, Delahay Street, Westminster, London, S.W. (E) Nov. 1887

K.

Keene, H. R., Lloyd's Register of Shipping, 2, White Lion Court, Cornhill, London, E.C. ... ... (E) { Graduate, May 1885 / Member, April 1887
Kendall, Stonard O., Lloyd's Register of Shipping, 342, Argyle Street, Glasgow ... ...(SUR) Mar. 1891
Kerfoot, James, 45, Rue de Grand Chila, Zurenberg, Antwerp ... (E) Oct. 1892
King, Donald, 22, Rothesay Gardens, Partick, Glasgow ... ... (E) Jan. 1890
King, John, 15, Nesham Street, Newcastle-on-Tyne... (S) { Graduate, Dec. 1890 / Member, Oct. 1892
Kirkaldy, John, 40, West India Dock Road, London ... ... (E) Nov. 1885
Kitching, J. F., 4, Hart Road, West Hartlepool ... ... (E) Nov. 1890

L.

Laing, Andrew, Oswald Gardens, Scotstounhill, Glasgow ... ... (E) Oct. 1892
Laing, Arthur, Deptford Shipyard, Sunderland ... ... (S) Nov. 1884
Laing, John, c/o Messrs. R. & W. Hawthorn, Leslie, & Co., St. Peter's, Newcastle-on-Tyne ... ... (E) Nov. 1884
Landreth, Cowen, 34, Simonside Terrace, Newcastle-on-Tyne ... (E) Mar. 1896
Larkin, James, Tyne View, East Jarrow-on-Tyne ... ... (E) Nov. 1884
Lewins, Frank, Rosehill, Willington Quay-on-Tyne ... ... (E) Dec. 1895
Lewis, R. A., Newburn Steel Works, Newburn-on-Tyne ... ... (E) Nov. 1884
Liddell, J., c/o Messrs. Denny & Co., Engine Works, Dumbarton (E) Nov. 1884
Lie, Gotfred, Det Bergenske Dampskibsselskab, Bergen ... ... (E) Jan. 1895
Lindfors, Hugo, Surveyor to Lloyd's Register of Shipping, 16, Alexandersgatan, Helsingfors, Finland ... ... (SUR) May 1889
Lineham, Wilfrid J., Jesmond, Leyland Road, Lee, London, S.E. (E) Oct. 1890
Linsley, Frederick, 5, Wentworth Terrace, South Shields... ... (E) Jan. 1896
List, John, Orchard House Works, Blackwall, London, E. ... (E) April 1891
Littleboy, Chas. Wm., 2, Lorne Terrace, Stockton-on-Tees ... (S) Oct. 1887
Littledale, John W. E., 65, Campbell Street, Newcastle-on-Tyne ... (E) May 1896
Livingston, Thos. L., Dunedin House, Jarrow-on-Tyne ... ... (S) Nov. 1884
Lohmeyer, H., 53, Crown Street, Newcastle-on-Tyne ... ... (E) Nov. 1884
Long, A. E., 124, Albert Road, Jarrow-on-Tyne ... ... (S) Nov. 1884
Lönnholm, Carl Gustaf A., Messrs. Oscarshamn Dry Dock Co, Oscarshamn, Sweden ... ... (N A) Jan. 1896
Loveridge, W. H., Milton Works, West Hartlepool .. ... (I & S M) Oct. 1888
Lowdon, David, Messrs. The Barry Dock, Cardiff ... ... (E) May 1894
Lowdon, John, Messrs. The Barry Graving Dock and Engineering Co., Limited, Barry Dock, near Cardiff ... ... (E) Dec. 1891

M.

MacColl, Hector, Strandtown, Belfast ... ... (E) Dec. 1890
Maccoy, John, 55, Larkspur Terrace, Newcastle-on-Tyne ... ... (E) Feb. 1886
MacDonald, David R., c/o Messrs. Sir W. G. Armstrong, Mitchell, & Co., Walker Shipyard, Newcastle-on-Tyne ... ... (S) Nov. 1891
Mace, W., 253, Albert Road, Jarrow-on-Tyne ... ... (E) Jan. 1886

ELECTED.

Macfarlane, Andrew, 18, John Street, Sunderland ... ... (E) Dec. 1890
MacGregor, John, 2, Michaelston Villas, Barrow-in-Furness ... (E) Mar. 1888
MacHaffie, John, 635, Terrace Place, Schenectady, New York, U.S.A. (E) Dec. 1885
Mackay, William, 11, Kilbirnie Cottages, Clydebank, Glasgow ... (S) Mar. 1892
Macoll, Hugh, 4, Azalea Terrace North, Sunderland (*Life Member*) (S) Nov. 1884
Mair, James, Wh. Sc., 39, Dockwray Square, North Shields ... (E) Oct. 1894
Manaira, Guiseppe, 4, Salita S Gerslamo, Genoa, Italy ... (E & N A) Nov. 1893
Marlborough, Richard, 44, Muirpark Gardens, Partick, Glasgow... (S) Nov. 1884
Marr, James, c/o Messrs. J. L. Thomson & Sons, North Sands Shipyard, Sunderland ... ... (S) Nov. 1884
Marshall, F. C., 38, Percy Gardens, Tynemouth ... ... (E) Nov. 1884
Marshall, Frank T., Messrs. R. & W. Hawthorn, Leslie, & Co., St. Peter's, Newcastle-on-Tyne ... ... (E) { Graduate, Jan. 1885; Member, Oct. 1888
Marshall, R. J., 51, Larkspur Terrace, Jesmond, Newcastle-on-Tyne (E) Mar. 1887
Mason, George F., Fairhaven, Clive Road, Penarth ... ... (E) Oct. 1895
Mastaglio, W. D., 65, Warrington Road, Newcastle-on-Tyne ... (E) Nov. 1885
Mather, Charles, 44, Warrington Road, Newcastle-on-Tyne ...(SUR) Oct. 1888
Matheson, William, c/o Messrs. R. & W. Hawthorn, Leslie, & Co., Hebburn-on-Tyne... ... ... (S) Dec. 1889
Matthews, A., Waterloo Road, Blyth... ... ... (S) Nov. 1884
Matthews, Jas., c/o Messrs. R. & W. Hawthorn, Leslie, & Co., Forth Banks, Newcastle-on-Tyne ... ... (E) Oct. 1886
McBride, William, Warren Cement Works Cottages, Hartlepool... (E) Dec. 1894
McDougall, Neil, Managing Director, Messrs. British Steam Users' Insurance Society, Ld., 4 & 5, Victoria Buildings, Manchester (E) Mar. 1890
McGlashan, Arch., Beechcroft, Clifton Avenue, West Hartlepool (S) Nov. 1885
McIlvenna, J. G., c/o Messrs. The Tyne Pontoons and Dry Docks Co., Wallsend-on-Tyne ... ... (S) Nov. 1884
McKay, Jno., 19, Victoria Avenue, Whitley-by-the-Sea ... ... (E) Nov. 1884
McKechnie, James, Messrs. Naval Construction and Armaments Co., Barrow-in-Furness .. .. (E) April 1896
McLaren, Robert M., Flinton Hill, Sunderland ... ... (S) Nov. 1893
McLaren, William, 8, London Grove, Prince's Road, Liverpool ... (E) Oct. 1894
McNeil, Thomas Young, 70, Meldon Terrace, Heaton, Newcastle-on-Tyne ... ... (S) Oct. 1895
Meldrum, Michael, Humbledon View, Sunderland ... ... (E) Dec. 1893
Menzies, Wm., The Side, Newcastle-on-Tyne ... ... (E) Nov. 1884
Messenger, Thomas, Paris House, Snargate Street, Dover, Kent ... (E) Mar. 1887
Metcalf, Thos., Jun., 18, John Street, Sunderland ... (S) { Graduate, May 1885; Member, Nov. 1893
Metcalfe, C. S., 24, Croft Avenue, Sunderland ... ... (E) Nov. 1884
Micheli, Pietro, Jun., Via Sottoripu, No. 1, piano nobile ... (E & N A) Oct. 1888
Middlemass, Thomas, 3, Albert Place, Norton Road, Stockton-on-Tees... ... ... (S) Oct. 1889
Middleton, H., 7, Chelsea Grove, Newcastle-on-Tyne ... (I & S M) Jan. 1893
Middleton, Robert Alexander, Fairfield Works, Govan, Glasgow... (N A) Oct. 1892
Milburn, Christopher J., Ovingham-on-Tyne ... ... (E) Feb. 1888
Millar, Thos., c/o Messrs. Sir W. G. Armstrong, Mitchell, & Co., Walker Shipyard, Walker-on-Tyne ... ... (S) Nov. 1884
Miller, Thomas B., Pier Head Chambers, Cardiff ... (E) { Graduate, Nov. 1886; Member, Oct, 1888

ELECTED.

Mills, John, c/o Messrs. Greenock Steam Shipping Co., Greenock ... ... (E) Feb. 1888
Mills, William, 16, St. George's Square, Sunderland ... ... (E) Feb. 1890
Milton, J. T., Lloyd's Register of Shipping, 2, White Lion Court, Cornhill, London, E.C. ... ... (E SUR) Nov. 1886
Moffatt, James, 7, Murray's Terrace, Belfast, Ireland (E) { Graduate, Dec. 1889 / Member, Oct. 1892
Moffitt, George, 42, Stanley Street, Blyth ... ... (S) Oct. 1888
Moffitt, Robert, 13, Grace Terrace, Sunderland ... ... (E) Dec. 1885
Moody, Thomas V., 7, The Grove, Gosforth, Newcastle-on-Tyne ... (E) Dec. 1887
Moore, Frederick, c/o Messrs. Wilson, Sons, & Co., Ld., Bahia ... (E) Oct. 1890
Moorsom, Frederick, Queen Terrace, Seaton Carew ... ... (S) Nov. 1893
Morch, C. J., 23, Archbold Terrace, Newcastle-on-Tyne ... ... (N A) June 1896
Morgan, W. H., 22, Rochdale Street, Wallsend-on-Tyne ... ... (E) Nov. 1884
Morison, D. B., 8, Albion Terrace, Hartlepool ... ... (E) Feb. 1885
Mörk, Peter, 31, Holsteinsgude, Copenhagen ... ... (E) Nov. 1884
Morrison, Robt., 5, Challoner Terrace, South Shields ... ... (E) Nov. 1886
Morrison, William, Lloyd's Register of Shipping, 2, White Lion Court, Cornhill, London, E.C. ... ... (E SUR) Oct. 1890
Morton, Richard Fraser, Lloyd's Register of Shipping, Newcastle-on-Tyne ... ... (E SUR) Oct. 1890
Mountain, William Chas., Messrs. Ernest Scott, Mountain, & Co., Close, Newcastle-on-Tyne ... ... (E E) Feb. 1889
Mudd, Thomas, Central Marine Engine Works, West Hartlepool (E) Mar. 1886
Muir, Alfred Edward, 13, Joannah Street, Sunderland ... ... (S) Mar. 1893
Muir, Robert, 11, Clarence Crescent, Whitley, near Newcastle-on-Tyne ... ...(SUR) Oct. 1886
Muir, Robert Home, 1, Lovaine Crescent, Newcastle-on-Tyne ... (S) Oct. 1892
Musgrave, Evers, 147, St. Owen Street, Hereford ... (E) { Graduate, Nov. 1891 / Member, Oct. 1895
Myles, David, Northumberland Engine Works, Wallsend-on-Tyne (E) Nov. 1884

N.

Nastoupil, John, Chief Engineer, Austro-Hungarian Navy, Marine Casino, Pola, Austria ... ... (E) Nov. 1890
Nevins, William, c/o S. Todd, Esq., c/o Messrs. R. & W. Hawthorn, Leslie, & Co., Hebburn-on-Tyne ... ... (E) Mar. 1894
Newitt, Leonard, 20, East Parade, Newcastle-on-Tyne ... ... (E E) Dec. 1887
Newton, Richard, Park Square, West Hartlepool ... ... (E) April 1889
Nicholls, H. E., 25, Churchill Street, Sunderland ... ... (E) Nov. 1893
Nichols, Walter W., 30, Denmark Street, Gateshead-on-Tyne ... (E) May 1895
Nicholson, John S., North View, Mowbray Road, Westoe, South Shields ... ... (E) Nov. 1893
Nicholson, Walter E., Hebburn Boiler Works, Hebburn-on-Tyne (B B) April 1896
Nicol, John M., 15, Linskill Terrace, North Shields ... ... (E) Nov. 1884
Nicolson, G. C., H.M.S. "Alexandra," Portland, Dorset (E) { Graduate, Oct. 1885 / Member, Oct. 1888
Noble, George, 7, Dean Street, Newcastle-on-Tyne... ... ... (E) May 1893
Noble, Harry, Northern Machine Tool Works, Brewery Lane, Felling-on-Tyne ... ... (E) Nov. 1888
Nodder, Joseph, 503, Pitsmoor Road, Sheffield ... ... (F M) May 1893

ELECTED.

Norman, W. S., Orchard House, Whitby, near Chester ... ... (E) Nov. 1884
Norton, Harold P., Engineer Corps U.S. Navy, Washington, U.S.A. ... ... (E) Oct. 1890
Noton, F. R., Lloyd's Register of Shipping, Bute Docks, Cardiff (S) Nov. 1884
Nunes, Enrique E., Engineer, Argentine Navy, 433, Calle Ayacucho, Buenos Ayres ... ... (E) April 1891

O.

O'Halloran, Timothy, 205, Avenue du Commerce, Antwerp, Belgium ... ... (E) Jan. 1895
Oliver, Hedley, 6, Tower Chambers, Water Street, Liverpool ... (E) Oct. 1892
O'Neil, J. J., 2, Erith Terrace, Sunderland ... ... (E) Nov. 1884
Orde, E. L., c/o Messrs. Sir W. G. Armstrong, Mitchell, & Co., Walker Shipyard, Newcastle-on-Tyne ... ... (E) Oct. 1887
Orlando, Chev. Giuseppe, Cantiere Navale, Fratelli Orlando, Leghorn ... ... (N A) Jan. 1893
Orr, Reginald, 18, Bulwer Street, Shepherd's Bush, London, W. ... ... (E) { Graduate, Mar. 1890; Member, Oct. 1892
Oxley, G., 39, Norman Terrace, Howdon-on-Tyne ... ... (S) Nov. 1884
Oxton, Walter, 96, Blackpool Street, Burton-on-Trent (E) { Graduate, Dec. 1890; Member, May 1894

P.

Pacey, John W., c/o Messrs. Midland Coal, Coke, & Iron Co., Apendale, near Newcastle, Staffordshire ... ... (E) Feb. 1888
Parsons, Hon. Charles A., Holeyn Hall, Wylam-on-Tyne ... ... (E E) Dec. 1887
Parsons, Harry F., 83, Cardigan Terrace, Heaton, Newcastle-on-Tyne ... ... (E) Dec. 1890
Pascoe, J. R., Tyrmont, Woodford Green, Essex (*Life Member*) ... (S) Dec. 1889
Patterson, Jas., West Lodge, Walker-on-Tyne ... ... (E) Nov. 1884
Pattison, Jos., 123, Bute Road, Cardiff ... ... (E) Nov. 1884
Paulson, John, Messrs. The Wm. Cramp & Sons' Ship and Engine Building Co.. Philadelphia, U.S.A. ... ... (S) Feb. 1886
Payne, Henry Fernie, c/o Messrs. Henry Fernie & Sons, Rumford Street, Liverpool ... ... (E) Dec. 1895
Peacock, Nicholas B. J., 30, Dingle Road, Tranmere Park, Birkenhead ... ... (E) Oct. 1892
Pendred, L. St. L., 186, Portland Road, Newcastle-on-Tyne... ... ... (E) { Graduate, Mar. 1894; Member, Oct. 1895
Penney, R. H., Board of Trade Offices, 79, Mark Lane, London, E.C. ... ... (S SUR) Nov. 1884
Pepper, W., Sunnyside, West Villas, Oxbridge Lane, Stockton-on-Tees .. .. (E) Nov. 1888
Petersen, John L., 18, Bellerby Terrace, West Hartlepool... ... (E) Oct. 1888
Petree, James, Lloyd's Register of Shipping, 2, White Lion Court, Cornhill, London, E.C. ... ... (N A SUR) Oct. 1885
Petrini, Giacomo Luigi, C.E., c/o Messrs. Gio Ansaldo & Co., Sestri-Ponente, Italy ... ... (N A) Nov. 1892
Petterson, Carl Edwin, 7, Vestra Hamngaten, Gothenburg, Sweden (E) Oct. 1891
Philipson, Roland, Tynemouth... ... ... (E) Dec. 1884

ELECTED.

Phillips, Walter, 28, Brownhill Road, Catford, London, S.E. (N A & E) Oct. 1886
Phorson, P., Glen Lea, Roker, Sunderland ... ... (S) Nov. 1884
Piaud, Leon, Bureau Veritas, 8, Place de la Bourse, Paris ... ... (N A) Nov. 1888
Pitt, Frederick William, 15, Wilberforce Terrace, Gateshead-on-Tyne... ... ... (E SUR) Oct. 1890
Plotnicki, E. C., The Avenue, Wallsend-on-Tyne ... ... (E) Nov. 1886
Poli, Rodolfo, Chioggia, Italy ... ... (N A) Jan. 1890
Potts, Cuthbert Ivan, 6, Rodsley Avenue, Gateshead-on-Tyne ... (E) Oct. 1895
Potts, Matthew, 86. Glen Terrace, Hebburn-on-Tyne . . ... (S) Dec. 1890
Potts, Robert, 11, Mount Pleasant, Deptford, Sunderland... ... (S) Oct. 1888
Powell, James Richard, Pier Head Chambers, Cardiff ... ... (C E) May 1894
Price, F. D., 6, Osborne Villas, Jesmond, Newcastle-on-Tyne (E & S) Oct. 1888
Price, John, 6, Osborne Villas, Jesmond, Newcastle-on-Tyne ... (S) Nov. 1884
Pringle, Alfred, 10, Somerset Terrace, Walker-on-Tyne (S) { Graduate, Dec. 1891 / Member, Jan. 1894
Pringle, James G., 10, Somerset Terrace, Walker-on-Tyne... ... (S) Oct. 1892
Prosser, James, 205, Albert Road, Jarrow-on-Tyne... ... ... (E) Nov. 1893
Purdon, Andrew S., Fairfield Works, Govan, Glasgow ... ... (S) Oct. 1892
Purdy, A. J., Philipson Street, Willington Quay-on-Tyne ... (E) Nov. 1884
Purves, David, Wyborne Gate, Westcliffe Road, Birkdale, Southport ... ...(SUR) Dec. 1885
Purvis, Fred. W., 5, Greatham Terrace, West Hartlepool ... ... (S) April 1893
Putnam, T., Darlington Forge, Darlington ... ...(F M) Nov. 1884
Putnam, William, Darlington Forge, Darlington ... ...(F M) Nov. 1884

Q.

Quicke, Herbert John, 5, Grazebrook Road, Clissold Park, London, N. ... ... (E) Feb. 1891

R.

Rae, John, 11, Gray Street, Glasgow, N.B. ... ... (E) April 1886
Ralston, G. C. ... ... (E) Oct. 1887
Ramage, J. T., St. Aubyn's, Bonnington, Edinburgh ... ... (E) April 1887
Ramage, John Anderson, 74, Glen Terrace, Hebburn-on-Tyne ... (S) Oct. 1892
Readhead, Jas., Beach View, South Shields ... ... (S) Nov. 1884
Readhead, John, 4, Salisbury Place, South Shields.. ... ... (E) Mar. 1886
Readhead, R., 28, Sea View Terrace, South Shields ... ... (E) Nov. 1884
Readhead, W. B., South-garth, Westoe, South Shields ... ... (S) Nov. 1886
Reavell, W., c o Messrs. Babcock & Wilcox, 147, Queen Victoria Street, London, E.C. ... ... (E) { Graduate, April 1885 / Member, Oct. 1887
Reed, Joseph, Angerton House, North Shields ... ... (E) Oct. 1889
Reed, J. W., c/o Messrs. Palmer's Shipbuilding and Iron Co., Limited, Engine Works Department, Jarrow-on-Tyne ... (E) Nov. 1884
Reed, Richard, c/o Messrs. Wigham Richardson & Co., Neptune Works, Walker-on-Tyne ... ... (S) Oct. 1894
Rennoldson, C., Messrs. J. P. Rennoldson & Sons, South Shields (S) Jan. 1886
Rennoldson, Jos. M., Messrs. J. P. Rennoldson & Sons, South Shields (S) Feb. 1886
Renton, John, 1, Akenside Hill, Newcastle-on-Tyne ... (M SUR) April 1895
Reynolds, Charles H., c/o Messrs. Sir W. G. Armstrong, Mitchell, & Co., Walker-on-Tyne ... ... (S) Mar. 1889

ELECTED.

Reynolds, W. G., 4, Ulfra Terrace, South Shields ... ... (E) Oct. 1886
Richardson, T., B.A., M.P., Hartlepool Engine Works, Hartlepool (E) April 1888
Rickaby, A. A., Bloomfield Engine Works, Sunderland ... ... (E) Mar. 1888
Ridley, J. H., Messrs. R. & W. Hawthorn, Leslie, & Co., St. Peter's, Newcastle-on-Tyne ... ... (E) Nov. 1884
Riley, J. H., Messrs. Riley Bros., Stockton-on-Tees ... ... (B B) May 1893
Ritson, M., Lloyd's Register of Shipping, 29, Regent Quay, Aberdeen ... ... (E SUR) Nov. 1884
Ritson, S. M., c/o J. H. Hallett, Esq., 123, Bute Docks, Cardiff ... ... (E) { Graduate, Nov. 1887; Member, Nov. 1893
Robinson, William, 7, Choppington Street, Newcastle-on-Tyne ... ... (E) { Graduate, May 1885; Member, April 1888
Robson, Arthur, Messrs. J. Blumer & Co., North Dock, Sunderland (S) Dec. 1886
Robson, George, 9, Wellington Terrace, South Shields ... ... (E) Oct. 1889
Robson, George, 140, Aurelian Terrace, South Shields ... ... (E) Feb. 1896
Robson, Geo. Edward, 61, Thornton Street, West Hartlepool ... (S) Nov. 1893
Robson, John H., Grainger Commercial Hotel, Newcastle-on-Tyne (E) Nov. 1885
Robson, J. M., 4, Abbey Terrace, Gateshead-on-Tyne ... ... (E) Nov. 1884
Robson, M., 23, Zion Terrace, Newcastle Road, Sunderland ... (S) Nov. 1884
Roger, Robert, Stockton Iron Foundry, West Row, Stockton-on-Tees (E) Nov. 1888
Rogers, Herbert M., Laurel Bank, Bromley Common, Kent (SUR) April 1889
Rolf, George, Lefroy House, Newcastle-on-Tyne ... ... (E E) May 1892
Rolland, Alexander, Villa Ruzic, Susak, Fiume, Hungary... ... (E) Mar. 1892
Ropner, Robert, Jun., Stockton-on-Tees ... ... (S) Feb. 1886
Roseti, S., 8, Radnor Place, Birkenhead ... ... (N A) June 1896
Ross, William, 20, Meadow Side, Dundee ... ... (E) May 1893
Rosser, W. D., Messrs. The Cardiff Pontoon Company, Mount Stuart Square, Cardiff ... ... (S) Nov. 1893
Rowan, Jas., 231, Elliott Street, Glasgow ... ... (E) Nov. 1886
Rowell, G. W., Simla House, New Benwell, Newcastle-on-Tyne ... (E) Feb. 1885
Rowell, H. B., Hebburn Hall, Durhamshire ... ... (S) Nov. 1884
Rusden, L., 14, Sanderson Road, Jesmond, Newcastle-on-Tyne ... (E) Nov. 1884
Russell, F. Herbert, Scotia Engine Works, Sunderland ... ... (E) Oct. 1891
Rutherford, G., Messrs. Mercantile Pontoon Co., Roath Dock, Cardiff ... ... (S) Oct. 1886
Rutherford, J. T., 123, Whiteman Road, Harringay, London (E) { Graduate, Jan. 1886; Member, Nov. 1893
Ryder, C. L., 53, James Street, Docks, Cardiff ... ... (E) Oct. 1886
Ryder, William J. H., Hartford Bridge House, Cramlington, R.S.O. (E) Oct. 1891

S.

Salmon, P., 5, The Oaks West, Sunderland ... ... (E SUR) Nov. 1884
Sambidge, James, c/o Messrs. J. H. Holmes & Co., Portland Road, Newcastle-on-Tyne ... ... (E E) Nov. 1891
Sandeman, John Watt, 2, St. Nicholas' Buildings, Newcastle-on-Tyne... ... ... (E) Oct. 1891
Sanderson, Henry Thomas Barron, Messrs. Sanderson & Co., High Quay, Blyth ... ... (E) Oct. 1891
Sanderson, J., 31, Park Road, Jarrow-on-Tyne ... ... (S) Nov. 1884
Sandison, M., 12, Beech Grove Road, Newcastle-on-Tyne ... ... (E) Dec. 1884
Sawyers, John, c/o Messrs. Thos. Wilson, Sons, & Co., Hull ... (E) Oct. 1886

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Schaeffer, A. G., 32, Side, Newcastle-on-Tyne ... ... (E) Nov. 1884
Scotson, Wm., Fair View, Wood Green Road, Wednesbury ... (E) Nov. 1884
Scott, Ernest, Close Engine Works, Newcastle-on-Tyne ... ... (E E) Nov. 1884
Scott, James, c/o Messrs. Consett Iron Co., Blackhill, Co. Durham (E) Oct. 1892
Scott, Joseph R., 9, Queen Street, Newcastle-on-Tyne ... ... (E) Oct. 1887
Scott, William, c/o Messrs. R. & W. Hawthorn, Leslie, & Co., St. Peter's, Newcastle-on-Tyne ... ... (E) Nov. 1884
Scott, William, 134, King's Road, Cardiff ... ... (E) June 1896
Scurlock, Thos. Henry, 12, Windsor Road, Barry, near Cardiff ... (S) Oct. 1890
Seabury, Edward, 40, West India Road, Limehouse, London, E. .. (E) Mar. 1886
Seaman, C. J., Fairfield, North Stockton-on-Tees ... ... (E) Jan. 1889
Seaton, Albert Edward, Messrs. Earle's Shipbuilding Co., Hull ... (E) Jan. 1891
Seddon, Joseph A., The British Corporation Registry of Shipping, 56, Mount Stuart Square, Cardiff ... ...(SUR) Mar. 1896
See, Horace, 1, Broadway, New York City, U.S.A.... ... ... (E) May 1896
Sells, C. Degrave, Cornigliano, Ligure, Italy ... ... (E) Oct. 1887
Shand, H., 39, Holly Avenue, Newcastle-on-Tyne... ... ... (E) Nov. 1884
Sharp, A. E., 16, Bede Burn Road, Jarrow-on-Tyne ... ... (E) Nov. 1884
Sharp, Mark, 144, Albert Road, Jarrow-on-Tyne ... ... (E) Dec. 1889
Shaw, Jas., 26, Sandhill, Newcastle-on-Tyne ... ... (M SUR) Jan. 1885
Sheriff, Thomas, c/o Messrs. Robert Mackill & Co., 29, Waterloo Street, Glasgow ... ... (E) April 1890
Short, J. Y., 49, West Sunniside, Sunderland ... ... (S) Nov. 1884
Short, Jos., 49, West Sunniside, Sunderland... ... ... (S) Nov. 1884
Shotton, John W., 32, Mount Stuart Square, Cardiff ... ... (SUR) Nov. 1886
Shute, A. E., 12, Clyde View, Partick, Glasgow ... ... (E) Dec. 1892
Sibun, William, Lloyd's Register of Shipping, Bute Docks, Cardiff (SUR) Mar. 1896
Sim, John Archibald, 1, South Cliffe, Roker, Sunderland ... ... (S) Jan. 1896
Simpson, Edward, Buddle Street, Wallsend-on-Tyne ... ... (S) Dec. 1890
Simpson, Kenneth, 41, Dalton Road, Barrow-in-Furness (S) { Graduate, Dec. 1893; Member, Oct. 1895 }
Sinclair, R., c/o Messrs. J. Wildridge & Sinclair, Consulting Engineers, 97, Pitt Street, Sydney, N.S.W., Australia ... (C E) Nov. 1884
Sinton, John K., 26, Sandhill, Newcastle-on-Tyne... ... ... (E) Nov. 1885
Sisson, Wm., Gloucester ... ... (E & N A) Oct. 1888
Sivewright, G. W., 5, Radcliffe Terrace, Hartlepool ... ... (S) Nov. 1886
Skinner, Leslie, Ravensbourne Terrace, South Shields (S) { Graduate, Dec. 1886; Member, Oct. 1891 }
Smith, C. E., 73, Thornton Street, West Hartlepool ... ... (E) Nov. 1888
Smith, Eustace, 5, Queen Street, Newcastle-on-Tyne ... ... (S) Nov. 1884
Smith, L. Eustace, 22, St. Mary's Place, Newcastle-on-Tyne... ... ... (E) { Graduate, Oct. 1889; Member, Oct. 1892 }
Smith, Thomas, Steam Crane Works, Old Foundry, Rodley, near Leeds (E) Oct. 1888
Smith, Thomas Edward, Messrs. John Smith & Sons, Newgate Street, Newcastle-on-Tyne ... ... (E) April 1885
Smith, Wm., 152, Roker Avenue, Sunderland M. ... ... (E) Nov. 1884
Soliani, Nabor, Sotto Direzione Delle Costruzioni Navali del Rº Cantiere di Castellammare di Stabi, Italy ... ... (S) Jan. 1885
Sowter, Isaac G., Messrs. The Cleveland Shipbuilding Co., Cleveland, Ohio, U.S. America ... ... (E) Jan. 1889
Spear, John, c/o Messrs. T. Wilson & Sons, Hull ... . (E) Oct. 1887
Spearman, Richard, Eachwick House, Dalton, Newcastle-on-Tyne (E) Feb. 1889

ELECTED.

Spence, W. G., c/o George Clark, Esq., Southwick Engine Works, Sunderland (*Life Member*) ... ... (E) Nov. 1884
Spencer, J. W., Newburn Steel Works, Newburn-on-Tyne ... (E) Feb. 1885
Stafford, William, 8, Tyne Vale Terrace, Bensham, Gateshead-on-Tyne ... ... (E) Nov. 1885
Stansfield, George R., The Grove, Westoe, South Shields ... ... (E) Mar. 1891
Stephen, A. E., Linthouse, Govan, Glasgow ... ... (E & S) June 1896
Stephen, John Murray, Northumberland Engine Works, Wallsend-on-Tyne ... ... (E) Oct. 1895
Stephenson, C., 2, Elm Terrace, The Green, Wallsend-on-Tyne ... (S) Nov. 1884
Stevenson, Wm., 27, Elton Street, Wallsend-on-Tyne ... ... (E) Nov. 1884
Stewart, James, 31, Lily Avenue, Jesmond, Newcastle-on-Tyne .. (E) Oct. 1890
Stirling, Andrew, Jun., 1, Greenvale Terrace, Dumbarton... ... (E) Feb. 1888
Stirzaker, J. C., 16, Grosvenor Place, Newcastle-on-Tyne... ... (E) Nov. 1884
Stoddart, J. E., Lloyd's Register of Shipping, White Lion Court, Cornhill, London, E.C. ... ... (E SUR) Oct. 1888
Stoddart, Swinton, 24, North Milburn Street, Sunderland (S) { Graduate, May 1885; Member, Nov. 1892 }
Stokoe, Thomas W., 55, Northcote Street, South Shields ... ... (S) Dec. 1885
Stone, Wm., 13, Rosslyn Terrace, Sunderland ... ... (S) Nov. 1884
Strong, George Aaron, 87, West Percy Street, North Shields ... (E) Dec 1889
Stroughair, John W. H., Whitewell Lane, Ryton-on-Tyne ... (E) Nov. 1894
Summers, James, 114, Grange Road West, Middlesbrough ... (E) Mar. 1889
Summersby, Robert Arthur, 4, Otterburn Terrace, Jesmond, Newcastle-on-Tyne ... ... (E) Oct. 1891
Surtees, Francis V., Westbourne Street, Stockton-on-Tees ... (S) Dec. 1892
Surtees, R., Frame House, Low Teams, Gateshead-on-Tyne ... (E) Nov. 1884
Swan, A. S., Grove House, Gosforth, Newcastle-on-Tyne ... ... (S) Nov. 1888
Swan, Charles Sheriton, c/o Messrs. C. S. Swan & Hunter, Wallsend-on-Tyne... ... ... (S) { Graduate, Nov. 1890; Member, Mar. 1894 }
Swan, H. F., North Jesmond, Newcastle-on-Tyne ... . (S) Nov. 1884
Swinburne, M. W., 117, Park Road, Newcastle-on-Tyne ... ... (E) Nov. 1884
Swinburne, T. M., Bewick Road, Gateshead-on-Tyne ... ... (E) Jan. 1885
Swinney, W., 10, Wentworth Terrace, Westoe Lane, South Shields (E) Dec. 1888
Sydserff, Thomas B., Jun., 68, Bath Road, Totterdown, Bristol ... (E) Oct. 1888
Syme, James, Fairfield Works, Govan, Glasgow ... ... (E) Oct. 1892

T.

Tate, Chas. H., 7, Side, Newcastle-on-Tyne ... ... (N A) Nov. 1884
Taylor, Alexander, Maritime Buildings, King Street, Newcastle-on-Tyne ... ... (E) Nov. 1884
Taylor, C. W., South Garth, Westoe, South Shields ... ... (E) April 1885
Taylor, John, 1, St. Alban's Place, Tynemouth ... ... (E) Dec. 1894
Thompson, C. E., Messrs. J. L. Thompson & Sons, North Sands, Sunderland... ... ... (S) Nov. 1884
Thompson, Charles, M.A., 33, Mosley Street, Newcastle-on-Tyne (E) Feb. 1887
Thompson, Jas., 2, Carlton Terrace, Sunderland ... ... (E) Dec. 1886
Thompson, John Augustus, 12, London Street, Fenchurch Street, London, E.C. ... ... (E & N A) Oct. 1892
Thompson, J. L., North Sands Shipyard, Sunderland ... ... (S) Nov. 1884

ELECTED.

Thompson, Robert, North Sands Shipyard, Sunderland ... ... (S) Nov. 1884
Thomson, James, M.A., c/o Messrs. Sir W. G. Armstrong, Mitchell, & Co., Ordnance Works, Elswick, Newcastle-on-Tyne (E & N A) Nov. 1890
Thorn, W. H., 5, Waterville Terrace, North Shields ... ... (E) Nov. 1884
Thornton, James, c/o Messrs. The Mercantile Dry Dock Co., Ltd., Jarrow-on-Tyne ... ... (E) April 1893
Tinn, Fred. D., 2, Sunningdale Terrace, South Shields ... ... (E) Nov. 1891
Todd, W. Surtees, c/o Messrs. R. & W. Hawthorn, Leslie, & Co., Hebburn-on-Tyne ... ... (S) Nov. 1884
Todd, Thomas, 110, Fenchurch Street, London, E.C. ... ... (E) Nov. 1385
Toovey, Alfred F., Ovington Cottage, Prudhoe, Northumberland (E) Dec. 1894
Topp, Carl, Schichan Werfl, Danzig, Germany ... ... (S) Oct. 1894
Towers, Edward, Jun., 4, Latimer Street, Tynemouth (E) { Graduate, Nov. 1886 / Member, Oct. 1888 }
Trail, John, 25, Sanderson Road, Jesmond, Newcastle-on-Tyne (M S) Oct. 1892
Trewent, F. J., 43, Billiter Buildings, Billiter Street, London, E.C. ... ... (S) Dec. 1884
Trowell, Wm. John, 37, Caroline Street, Jarrrow-on-Tyne ... (E) Oct. 1894
Tulip, George, Universities Mission, Lake Nyassa, Central Africa (E) Dec. 1888
Turnbull, Charles, Jun., Hylton Lodge, North Shields ... ... (E E) Oct. 1894
Turner, S. J., 71, Warwick Street, Heaton, Newcastle-on-Tyne ... (E) Mar. 1887
Turpie, David Whyte, c/o Messrs. W. Pickersgill & Sons, Southwick, Sunderland ... ... (S) Dec. 1895
Twaddell, James L., 4, St. John's Terrace, Jarrow-on-Tyne ... (S) Oct. 1891
Tweedy, J., Neptune Works, Walker-on-Tyne ... ... (E) Nov. 1884
Twigden, George J., c/o Messrs. Hick Bros., Mount Stuart Square, Cardiff ... ... (E) Jan. 1890
Tyzack, George, Dean Street, South Shields... ... ... (E) April 1888

U.

Ullstrom, Otto, 84, Leadenhall Street, London, E.C. ... ... (S) Nov. 1884
Ulm, John, The Arsenal, Pola, Austria ... ... (E) Nov. 1885

V.

Vianson, N. E., *viâ* Corsica 20/1, Genoa, Italy ... ... (E) Dec. 1885
Vick, R. W., Messrs. Furness, Withy & Co., Middleton Shipyard, West Hartlepool ... ... (S) Nov. 1888
Vivet, Leon, 47, Rue St. Andre de Arts, Paris ... ... (N A) Nov. 1892

W.

Wadagaki, Yasuzo, Imperial Naval Dockyard, Yokosuka, Japan ... (E) Jan. 1891
Wailes, T. W., Mount Stuart Dry Docks, Cardiff ... ... (E & S) Oct. 1887
Wait, Thomas Herbert, Cail's Buildings, Quayside, Newcastle-on-Tyne ... ... (C E) Dec. 1893
Wake, Tom, 2, Cliff Terrace, Hartlepool ... ... (E) April 1892
Wakeham, John F., 38, King John Street, Newcastle-on-Tyne... ... ... (S) { Graduate, Mar. 1893 / Member, Oct. 1895 }
Walker, Archibald, Elizafield House, North Fort Street, Leith, N.B. (E) April 1887
Walker, Henry, 11, Oxford Terrace, Gateshead-on-Tyne ... ... (E E) Feb. 1893

ELECTED.

Walker, John, c/o Messrs. R. Stephenson & Co., Limited, South Street, Newcastle-on-Tyne ... ... (E & S) Nov. 1891
Wallau, J., c/o Messrs. Black, Hawthorn, & Co., Gateshead-on-Tyne (E) Nov. 1884
Walliker, J. F., Lloyd's Register of Shipping, Bute Docks, Cardiff (E) Nov. 1885
Walliker, John George, Barry, near Cardiff ... ... (E) May 1896
Wallis, Robert, Wh.Sc., Point Pleasant House, Wallsend-on-Tyne (E) April 1891
Walter, Max, Norddeutscher Lloyd, Central Bureau, Bremen ... (S) Feb. 1893
Walton, J. G., 26, Fenchurch Street, London, E.C. ... ... (E) Nov. 1884
Walton, Samuel, 34, Pollard Street, South Shields ... ... (E) Dec. 1893
Warburton, J., 9, Foyle Street, Sunderland ... ... (E) Nov. 1884
Ward, John, c/o Messrs. W. Denny & Bros., Dumbarton ... ... (S) Dec. 1891
Ward, Mark M., 76, Church Street, West Hartlepool ... ... (E) Dec. 1893
Wardale, Henry, 5, Collingwood Terrace, Gateshead-on-Tyne ... (E) Feb. 1888
Warden, Thomas M., 21, Windermere Street, Gateshead-on-Tyne (E) Oct. 1894
Watson, Thomas Henry, 10, Neville Street, Newcastle-on-Tyne ...(SUR) Jan. 1896
Watt, Robert B., c/o Messrs. Sir Raylton Dixon & Co., Cleveland Shipyard, Middlesbrough ... ... (S) April 1888
Watts, Philip, Elswick Shipyard, Newcastle-on-Tyne ... ... (S) Nov. 1885
Weidemann, Nils, Det-Norske Veritas, Christiania, Norway ...(SUR) Jan. 1892
Weighton, R. L., M.A., Durham College of Science, Barras Bridge, Newcastle-on-Tyne ... ... (E) Nov. 1884
Weir, George Dobie, Northumberland Engine Works, Wallsend-on-Tyne ... ... (E) Oct. 1894
Weir, John, c/o Messrs. J. Scott & Co., Abden Works, Kinghorn, N.B. ... ... (E) Nov. 1884
Weir, William, c/o Messrs. Wigham Richardson & Co., Walker-on-Tyne ... ... (E) Nov. 1889
Welton, J. G., 12, Hendon Valley Road, Sunderland ... ... (E) Nov. 1893
West, Henry H., British and Foreign Chambers, 5, Castle Street, Liverpool ... ... (E & N A) Oct. 1886
Westgarth, Tom, Messrs. Westgarth, English, & Co., Middlesbrough (E) Oct. 1886
Westmacott, Alfred, Benwell Hill, Newcastle-on-Tyne (E) { Graduate, Dec. 1885; Member, Nov. 1892 }
Westmacott, P. G. B., Benwell Hill, Newcastle-on-Tyne ... ... (E) Nov. 1884
Wheater, Chas. Busfield, 22, Victoria Street, Newcastle-on-Tyne (E) Oct. 1894
Wheeler, Oswald ... ... (E) { Graduate, Oct. 1886; Member, Oct. 1892 }
White, C., 13, Mosley Street, Newcastle-on-Tyne ... ... (E) Nov. 1884
White, Ernest T., 6, Rydal Street, Gateshead-on-Tyne (E) { Graduate, May 1889; Member, Jan. 1894 }
White, R. S., Walker Shipyard, Walker-on-Tyne ... ... (S) Nov. 1884
Whitfield, Thomas, Messrs. Tyne Dock Engineering Co., South Shields ... ... (E) April 1896
Whittaker, Frederick W., Dockyard, Messrs. Mersey Docks and Harbour Board, Liverpool ... ... (E) Oct. 1892
Whyte, Wm., B, Lombard Street, Newcastle-on-Tyne ... ... (E) Nov. 1884
Widdas, T. D., 56, Plasturton Avenue, Cardiff ... ... (SUR) April 1885
Wilkie, J., 24, Camden Street, Southwick, Sunderland ... ... (E) Nov. 1884
Williams, T. Fitzroy, Board of Trade Offices, North Shields ... (E) Feb. 1890
Williams, Thomas R., 178, Bede Burn Road, Jarrow-on-Tyne ... (S) Oct. 1895
Wilson, Henry J. H., 117, Bede Burn Road, Jarrow-on-Tyne ... (E) Nov. 1895
Wilson, James, Messrs. G. Clark & Co., Southwick, Sunderland ... (E) Jan. 1896

ELECTED.

Wilson, John Paul, Messrs. Palmer's Shipbuilding Co., Jarrow-on-Tyne... ... ... (S) Oct. 1895
Wilson, Thomas, 6, Aiskell Street, Sunderland ... ... (E) Oct. 1895
Wimble, Arthur, c/o Messrs. Wigham Richardson & Co., Neptune Works, Walker-on-Tyne ... ... (E) Dec. 1893
Winstanley, P. D., Bureau Veritas Register of Shipping, 155, Fenchurch Street, London ... ... (S) Nov. 1884
Winter, Thor., Skeppsdockan, Helsingfors, Finland ... ... (E) Nov. 1893
Withy, H., Middleton Shipyard, West Hartlepool ... ... (S) Nov. 1884
Wood, Henry Alfred, The Longlands, Middlesbrough-on-Tees ... (S) Dec. 1893
Wood, Joseph, Foundry Manager, Deptford Yard Brass Works, Sunderland... ... ... (E) Mar. 1895
Wortley, Henry B., 23, Bedford Road, Rock Ferry, Birkenhead ... ... (S) { Graduate, Jan. 1886; Member, Nov. 1892 }
Wray, Thomas W., Board of Trade Offices, Sunderland ... ...(SUR) Jan. 1895
Wright, R., 5, Hawthorn Terrace, Newcastle-on-Tyne ... ... (E) Nov. 1884

Y.

Young, Andrew, Bureau Veritas Register of Shipping, 155, Fenchurch Street, London, E.C. ... ... (S) { Graduate, Feb. 1892; Member, May 1893 }
Young, J. Denholm, 2A Tower Chambers, Liverpool ... ... (E) Oct. 1888
Younger, R., Elmire House, Heaton, Newcastle-on-Tyne ... ... (E) Nov. 1884

Z.

Zeeman, J. H., 5, Willemsplein, Rotterdam ... ... (S) Oct. 1889

ASSOCIATES.

A.

Adam, John B., 8, Osborne Terrace, Newcastle-on-Tyne ... ... (O) Nov. 1893
Anderson, Daniel G., Burnaby Lodge, Ryton-on-Tyne ... ... (A) Nov. 1893
Armstrong, S., Beaconsfield Street, Hartlepool ... ... (A) Nov. 1888
Arnott, James, 25, Dean Street, Newcastle-upon-Tyne ... ...(S O) Oct. 1895

B.

Bacon, William Charles, Chadwick House, West Hartlepool ...(S O) Dec. 1890
Ball, Alfred F., 14, Landsdowne Terrace, Gosforth, Newcastle-on-Tyne... ... ... (A) Nov. 1894
Barklam, George, 167, Dudley Port, Tipton, Staffordshire ... (A) April 1888
Barr, John Smith, 5, Mosley Street, Newcastle-on-Tyne ... ... (A) Nov. 1893
Barwick, J. S., Ashbrook Grange, Sunderland ... ...(S O) Nov. 1884
Bell, John Henry, 39, Albert Drive, Pollokshields, Glasgow (I & S M) Oct. 1887
Beynon, Thomas, 9, Dean Street, Newcastle-on-Tyne ... ... (E A) Oct. 1891
Bigge, C. W., Northern Counties Club, Newcastle-on-Tyne ... (A) Dec. 1889
Bingham, Col. J. E., Manufacturer, West Lea, Sheffield .. ... (M) Mar. 1895
Bird, William, 8, Latimer Street, Tynemouth ... ... (A) May 1896
Blacklin, Richard James, Dinsdale House, Brougham Terrace, West Hartlepool ... ...(S O) Dec. 1890

ELECTED.

Briggs, R. S., Moorlands, Sunderland ... ... (S O) Dec. 1886
Brims, D. N., 4, St. Nicholas' Buildings, Newcastle-on-Tyne ... (C) Nov. 1893
Brunton, John, 3, Prior's Terrace, Tynemouth ... ... (S O) Oct. 1886
Bullen, Tempest C., c/o Messrs. H. E. Moss & Co., K, Exchange Buildings, Newcastle-on-Tyne ... ... (S O) Nov. 1891

C.

Caminos, T. L., Overseer, Argentine Navy, Grand Hotel, Newcastle-on-Tyne ... ... June 1896
Carr, Ralph, Thornleigh, Clayton Road, Newcastle-on-Tyne (A & S O) Nov. 1886
Cassap, William, 15, East Field Road, Walthamstow, Essex ...(SUR) Feb. 1890
Caws, Frank, 22, Fawcett Street, Sunderland ... ... (C E) Oct. 1892
Cohan, Edward Asher, 2, Rumford Place, Liverpool ... ... (S O) Nov. 1889
Common, Francis James, 5, Elms West, Sunderland ... (I & S M) Oct. 1887
Cooper, Charles, Average Adjuster, Wellington Road, West Hartlepool ... ... (A A) April 1893
Corbitt, Michael, Springfield, Gateshead-on-Tyne ... ... (R M) Jan. 1890
Cory, John, Cardiff ... ... (S O) June 1896
Coull, John, 43, Stanley Street West, North Shields ... ... (S O) Oct. 1886
Coverdale, R. H., Messrs. J. Coverdale & Sons, Steamship Owners, West Hartlepool ... ... (S O) Nov. 1888
Craik, A., Messrs. Blyth Dry Dock, Limited, Blyth ... ... (A) June 1896
Crosier, Edward James, 3, The Hawthorns, East Boldon ... ... (A) Oct. 1889
Culliford, J. H. W., 45, West Sunniside, Sunderland ... ... (S O) Nov. 1884

D.

Dodds, A. P., 13, Dean Street, Newcastle-on-Tyne ... ... (A) Jan. 1889
Dodds, E. F., 36, Side, Newcastle-on-Tyne ... ... (A) Nov. 1893
Dodds, John B., 36, Side, Newcastle-on-Tyne ... ... (CHEM) Oct. 1888
Dove, Edward John, 5, St. Nicholas' Buildings, Newcastle-on-Tyne (M) Oct. 1890

E.

Eccles, Edward, Royal Insurance Buildings, Queen Street, Newcastle-on-Tyne (*Life Associate*)... ... ... (S O) Oct. 1887

F.

Frazer, Joseph, Britannia Buildings, Cardiff ... ... (M) June 1896
Furness, Sir Christopher, Baltic Chambers, West Hartlepool ... (S O) Oct. 1888

G.

Graham, Frank, Bank Chambers, Mosley Street, Newcastle-on-Tyne ... ... (E A) Nov. 1891

H.

Hardy, John, Jun., Brunswick Street, West Hartlepool ... ... (I M) Nov. 1893
Harland, George, 1, Westoe Crescent, South Shields ... ... (A) Dec. 1888
Harrison, Thomas, 9, Bridge Street, Sunderland ... ... (A) Dec. 1894

ELECTED.

Hedley, John H., 10, Esplanade West, Sunderland ... ... (S) Dec. 1886
Henzell, Robert, Northern Oil Works, Close, Newcastle-on-Tyne (*Life Associate*) ... ... (A) Nov. 1893
Heslop, Richard O., Akenside Hill, Newcastle-on-Tyne ... (I & S M) Oct. 1885
Hodge, W. P., c/o Messrs. John Cory & Sons, Mount Stuart Square, Cardiff ... ...(M S) Mar. 1896
Hogg, John Thomas, Bute Docks, Cardiff ... ... (I & S M) April 1896
Holliday, Henry, Beechgrove, Blackhill, Co. Durham ... ... (A) Nov. 1895
Hollis, H. E., 23, Lilybank Gardens, Hillhead, Glasgow ... (I & S M) Feb. 1885
Hudson, Ralph M., Jun., 8, The Cedars, Sunderland ... ... (S O) Dec. 1886
Hudson, Robert, 24, Hotspur Street, Tynemouth ... ... (A) Nov. 1895
Hunting, Charles, 1, Exchange Buildings, Quayside, Newcastle-on-Tyne ... ... (S O) April 1886
Hurrell, Sidney E., Printing Court Chambers, Newcastle-on-Tyne (A) Nov. 1893

I.

Innes, Charles H., Rutherford College, Newcastle-on-Tyne ... (E) Oct. 1891

J.

Jenkins, Alfred, Tweed House, Victoria Terrace, Jarrow-on-Tyne (A) Nov. 1893
Johnson, W. J., c o Messrs. Robert Stephenson & Co., South Street, Newcastle-on-Tyne ... ... (A) May 1889
Jordan, John George, 24, Stansfield Street, Sunderland ... ... (A) Nov. 1892

K.

Kemp, James, Baltic Chambers, Newcastle-on-Tyne ... ...(S O) Feb. 1896

L.

Lennard, William, c/o Messrs. J. M. Lennard & Sons, Middlesbrough ... ... (S) Dec. 1891
Lloyd, John, Deptford Shipyard, Sunderland ... ... (A) Oct. 1894
Lockie, John, 4, Sanderson Road, West Jesmond, Newcastle-on-Tyne... ... ...(S O) Oct. 1892
Lodwidge, Philip, Baltic Chambers, Sunderland ... ... (A) June 1896

M.

Macarthy, George E., 9, Dean Street, Newcastle-on-Tyne... ...(S O) Oct. 1887
Mail, Douglas B., 14, Humbleton View, Sunderland ... ...(M S) Feb. 1895
Maughan, Thos., Jun., Hollyfield House, Sorley Street, Sunderland (A) Nov. 1893
Maughan, William, 13, Mosley Street, Newcastle-on-Tyne ... (A) Feb. 1887
McIntosh, R. Y., 53, Quayside, Newcastle-on-Tyne ... ... (E A) Nov. 1891
McIntyre, John, 3, Abbotsford Terrace, Newcastle-on-Tyne ... (S O) Jan. 1885
Meek, John George, 13, Belle Vue Park, Sunderland ... ... (A) Dec. 1894
Metcalf, Thomas, 18, John Street, Sunderland ... ...(SUR) Jan. 1888
Milburn, J. D., Queen Street, Newcastle-on-Tyne ... ... (S O) Nov. 1884
Miller, T. R., 9, Great St. Helen's, London, E.C ... ... (A & S O) Nov. 1884
Mitcalfe, John Stanley, Chairman of Northern Maritime Insurance Co., Maritime Buildings, Newcastle-on-Tyne ... ... (A & S O) Jan. 1892
Morton, Benjamin, 29, Azalea Terrace N., Sunderland ... ...(SUP) Dec. 1895

ELECTED.

Muir, James, 2, Dingle Lane, Liverpool ... ... (M S) Nov. 1893
Mulherion, G. F., 3, Rothbury Terrace, Heaton, Newcastle-on-Tyne ... ... (A) Nov. 1884
Muller, J. C. F., 28, Vieille Route, Antwerp ... ...(SUR) Feb. 1890
Murray, Matthew, The Green, Wallsend-on-Tyne ... ... (A) Nov. 1893

N.

Nicholson, John, 7, Side, Newcastle-on-Tyne ... ... (M S) Nov. 1890
Nixon, John, c/o Messrs. Blyth Shipbuilding Co., Blyth ... ... (A) Oct. 1894

O.

O'Hagan, James, 99, Quai de la Fosse, Nantes, France ... ... (A) Oct. 1888
Olsen, Hans Benedick, 70, Church Street, West Hartlepool ... (S O) Mar. 1893
Osbourne, Jas., 11, The Oaks, Sunderland ... ... (S) Jan. 1885

P.

Patterson, Thos., 2, The Elms, Sunderland ... ... (S) Jan. 1885
Perry, Edwin, Queen Street, Newcastle-on-Tyne ... ... (A) Nov. 1885
Petersen, Ferd. William, Messrs. Petersen & Tate, Bank Chambers, Sandhill, Newcastle-on-Tyne ... ... (S O) Nov. 1893
Phalp, Oliver, Almora, 37, Richmond Road, Cardiff ... . (SUR) Feb. 1889
Pinkney, Thomas, 3, Ashbrook Terrace, Sunderland ... ...(S O) Dec. 1886
Pirrie, Robert Reid, Baltic Chambers, Quayside, Newcastle-on-Tyne (S O) Dec. 1889
Proctor, J. H., 22, Hawthorn Terrace, Newcastle-on-Tyne ... (I M) Nov. 1893

R

Radcliffe, Daniel, Cardiff ... ... (S O) June 1896
Radcliffe, Henry, Cardiff ... ... (S O) June 1896
Radloff, Captain O., c/o Messrs. R. & W. Hawthorn, Leslie, & Co., Limited, Shipyard, Hebburn-on-Tyne ... ... (M S) Nov. 1891
Ramsay, J. W., 13, Northbrook Road, Lee, Kent ... ... (A) Feb. 1885
Reichwald, A., Lombard Street, Newcastle-on-Tyne ... ... (A) Nov. 1884
Reid, Andrew, Printer, Akenside Hill, Newcastle-on-Tyne ... Nov. 1884
Renwick, G., Messrs. Fisher, Renwick, & Co., Maritime Buildings, King Street, Newcastle-on-Tyne ... ... (S O) Nov. 1884
Rickinson, John, 9, Church Street, West Hartlepool ... ... (S O) Nov. 1890
Riddle, John C., 60, Grey Street, Newcastle-on-Tyne ... ... (A) May 1896
Robson, Frederick, 46, Dean Street, Newcastle-on-Tyne ... (S I M) Oct. 1887
Robson, John William, G, King Street, Newcastle-on-Tyne ... (M) April 1896
Robson, Thos., Causeway House, Sunderland ... ...(S O) Nov. 1884
Runcieman, John Finley, Village Terrace, Westoe, South Shields (M S) Nov. 1892
Runciman, Walter, Fernwood House, Clayton Road, Newcastle-on-Tyne ... ... (S O) May 1895

S.

Scholefield, A., 17, Sandhill, Newcastle-on-Tyne ... ...(S O) Nov. 1884
Scott, W. H., Messrs. Scott Brothers, Dean St., Newcastle-on-Tyne (S O) Nov. 1884
Snowdon, W. F., 32, Side, Newcastle-on-Tyne ... ... (E A) Dec. 1886
Squance, J. W., 13, The Avenue, Sunderland ... ... (M S) April 1888

ELECTED.

Storey, Christopher, 28, Holly Avenue, Jesmond, Newcastle-on-Tyne... ... ... (A) April 1896
Swan, Isaac J., Grove House, Gosforth, Newcastle-on-Tyne ... (S O) Feb. 1888

T.

Tate, Arthur, Messrs. Petersen & Tate, Bank Chambers, Sandhill, Newcastle-on-Tyne ... ... (O) Nov. 1893
Thompson, V. T., Baltic Chambers, Sunderland ... ...(S O) Dec. 1886
Todd, John Stanley, Percy Park, Tynemouth ... ... (U) Nov. 1895
Towers, Edward, 4, Latimer Street, Tynemouth ... ... (A) Oct. 1888
Turner, Edwin, 32, Powell Road, Clapton, London, N.E. ... ... (A) Oct. 1895

W.

Wade, Wentworth S., 2, Otteran Place, South Parade, Waterford (M S) April 1895
Wait, James, Maritime Buildings, King Street, Newcastle-on-Tyne (S O) Nov. 1884
Walker, James, 87, Jesmond Road, Newcastle-on-Tyne ... ... (S O) Mar. 1894
Watson, Thomas W., Gisburn House, Hartlepool ... ...(M S) Nov. 1890
Weatheral, Henry, 27, Alderson Street, West Hartlepool ... ... (A) Feb. 1893
Whitfield, John, Blyth ... ... (S) Nov. 1895
Wight, Robert M., 42, The Exchange, Cardiff ... ... (M) June 1896
Wilson, F. Alfred, 45, West Sunniside, Sunderland ... ... (I M) Nov. 1893

Y.

Yeoman, F., Messrs. Murrell & Yeoman, West Hartlepool ...(S O) Nov. 1888
Younger, Robert Laurie, Messrs. Greenock Steamship Co., Limited, Greenock ... ... (A) Feb. 1889

GRADUATES.

A.

Adams, Cecil Turner, 6, Mutual Street, Wallsend-on-Tyne ... (E) Oct. 1891
Adams, Dawson, Brinkburn Terrace, Westoe, South Shields ... (E E) Oct. 1894
Andrew, David, Jun., 33, Osborne Road, Newcastle-on-Tyne ... (E) Oct. 189
Ashton, Arthur W., 33, Leazes Terrace, Newcastle-on-Tyne ... (E) Dec. 1894

B.

Baker, Ernest F., Assistant Engineer, H.M.S. "Nile," Mediterranean Fleet, Malta ... ... (E) Nov. 1892
Barbour, John, 1, Logan Terrace, South Shields ... ... (E) Nov. 1890
Beale, Harry, Otterburn Terrace, Newcastle-on-Tyne ... ... (S) Jan. 1891
Beilby, Norman Harry, 1, Kingsley Place, Heaton, Newcastle-on-Tyne ... ... (E) Dec. 1893
Bent, John Bradbury, 5, Worsley Road, Swinton, Manchester ... (E E) May 1894
Bentham, Frederick Lister, 9, Bellegrove Terrace, Newcastle-on-Tyne... ... ... (E) Dec. 1892
Binns, Aubrey B., 23, Thornhill Terrace, Sunderland ... ... (E) Oct. 1894

ELECTED.

Borthwick, Robert J., 8, Kensington Terrace, Newcastle-on-Tyne (E) Dec. 1894
Boswell, Cecil Robert, Frances Villa, Highfield Road, Dartford ... (E) Nov. 1893
Bowden, John, c/o Messrs. Sharp, Stewart, & Co., Springburn, Glasgow ... ... (E) Jan. 1894
Brown, George M., 16, Holly Street, Jarrow-on-Tyne ... ... (E) April 1895
Brown, Thomas Scott, Jun., 18, Nixon Street, Newcastle-on-Tyne ... ... (E) Oct. 1895
Bryers, Charles, 10, The Avenue, Sunderland ... ... (E) Dec. 1892
Bulmer, Albert Edward, 1, Graingerville North, Newcastle-on-Tyne... ... ... (E) Nov. 1895
Bulmer, Septimus, 1, Graingerville North, Newcastle-on-Tyne ... (E) May 1894
Burbidge, Alfred H., 15, North View, Heaton, Newcastle-on-Tyne... ... ... (E) Oct. 1895
Burn, Donald B., 7, The Elms West, Sunderland ... ... (S) Nov. 1893

C.

Cadman, C. C., 23, Lovaine Crescent, Newcastle-on-Tyne... ... (E) Nov. 1891
Cairns, Charles W., 84, Addison Road, Heaton, Newcastle-on-Tyne (E) Nov. 1894
Carpmael, Richard Herbert, 12, Grove Street, Newcastle-on-Tyne (E) Jan. 1893
Carr, Ralph, Jun., Thornleigh, Clayton Road, Newcastle-on-Tyne (E) Jan. 1894
Carter, Thomas, Belle Vue Park, Sunderland ... ... (E) Nov. 1891
Carter, Thomas, 6, Larkspur Terrace, Newcastle-on-Tyne... ... (E) Oct. 1895
Chapman, John Frederick, 44, Falconar Street, Newcastle-on-Tyne (E E) Dec. 1895
Coatsworth, George S., Oaks West, Sunderland ... ... (E) Nov. 1891
Cole, Alfred, 5, Holmside Place, Heaton, Newcastle-on-Tyne ... (E E) Jan. 1896
Cookson, John Annable, 2, St. Edmund's Road, Gateshead-on-Tyne (E) Dec. 1895
Crawford, J. F., "Palmyra," St. George's Road, Waterloo, near Liverpool ... ... (E) Nov. 1893
Crawhall, Henry F., 30, West Parade, Newcastle-on-Tyne ... (E E) May 1894
Crombie, W. Alan D., 18, Archbold Terrace, Newcastle-on-Tyne... (E E) Oct. 1894

D.

Davison, William H. G., 49, Sanderson Road, West Jesmond, Newcastle-on-Tyne ... ... (E) Dec. 1892
Dixon, William John, 10, Granville Road, Newcastle-on-Tyne ... (E) Mar. 1896
Dobson, Henry James, c/o Messrs. William Dobson & Co., Walker-on-Tyne, R.S.O. ... ... (S) Oct. 1891
Dobson, William Gordon, The Cnesters, Jesmond, Newcastle-on-Tyne... ... ... (S) Feb. 1896
Dodds, John Hanbury, c/o Mrs. Smith, North Terrace, Wallsend-on-Tyne ... ... (E) Feb. 1896
Donovan, John, 5, Ash Place, Sunderland ... ... (E) Dec. 1892
Duckitt, Louis, Leazes Gate Villa, Spital Tongues, Newcastle-on-Tyne ... ... (E) Oct. 1895
Duckitt, Talbot, Leazes Gate Villa, Spital Tongues, Newcastle-on-Tyne ... ... (E E) Oct. 1891

E.

Edminson, Frank A., 94, Ramsden Street, Barrow-in-Furness ... (S) Nov. 1893

ELECTED.

F.

Featherstonhaugh, Albany, 13, Park Place West, Sunderland ... (E) Oct. 1894
Ford, Hugh M., Assistant Engineer, R.N., H.M.S. "Trafalgar," Mediterranean Squadron, Malta... ... ... (E) Nov. 1893
Forster, Edgar S., 2, Shaftesbury Terrace, Gateshead-on-Tyne ... (E) Jan. 1894
Forster, L. P., 23, Lovaine Crescent, Newcastle-on-Tyne ... ... (E) Nov. 1893
Fraser, John H., New Winning Tavern, Wallsend-on-Tyne ... (E) Oct. 1895

G.

Gibson, Thomas, 162, Roker Avenue, Monkwearmouth, Sunderland (E) Nov. 1893
Golledge, W., 39, Eastgate Street, Gloucester ... ... (E) Nov. 1891

H.

Hancock, Bede, St. Bede's Vicarage, Sunderland, M. ... ... (E) Dec. 1894
Harvey, Herbert B., 26, Heaton Grove, Heaton, Newcastle-on-Tyne... ... ... (E) Jan. 1896
Hepburn, James M., 17, Grosvenor Place, Jesmond, Newcastle-on-Tyne ... ... (E) Nov. 1895
Hewitt, John, 29, Holly Street, Jarrow-on-Tyne ... ... (S) Nov. 1890
Hick, Charles, 2, Garibaldi Terrace, South Shields ... ... (E) Oct. 1894
Hinchliffe, Robert, 25, Hawthorn Street, Newcastle-on-Tyne ... (S) Nov. 1893
Hudson, Charles J., 84, Addison Road, Heaton, Newcastle-on-Tyne... ... ... (E) Nov. 1894
Hughes, Thomas C., 3, Summerhill Street, Newcastle-on-Tyne ... (E) Nov. 1893

J.

Jepson, Henry, 34, St. Mary's Place, Newcastle-on-Tyne ... ... (E) Nov. 1893

K.

Kennedy, Robert Sinclair, 8, Granville Street, Gateshead-on-Tyne (E) April 1893
Kent, Samuel N., Lindenhurst, Heaton, Newcastle-on-Tyne ... (E) Mar. 1896
Kitchin, Arnold, Marine Parade, East Hartlepool .. .. (E) Dec. 1892

L.

Lace, Basil Theodore, 92, Cardigan Terrace, Heaton, Newcastle-on-Tyne ... . (E) Nov. 1895
Laing, Bryan, Thornhill, Sunderland ... ... (S) Dec. 1895
Laing, Hugh, Thornhill, Sunderland ... ...(N A) Dec. 1894
Leighton, James, 17, Eversley Place, Heaton, Newcastle-on-Tyne ... ... (E) Jan. 1896
Lishman, John James, Jun., 16, Lovaine Place, North Shields ... (E) Dec. 1892
Lumley, William, 38, Sidney Grove, Gateshead-on-Tyne ... ... (E) June 1896
Lynn, John Robert Dent, 31, General Gordon Terrace, Sunderland (E) April 1893

M.

Macdonald, William C., 15, Union Street, Hartlepool ... ... (E) Mar. 1895
Mace, Charles, 253, Albert Road, Jarrow-on-Tyne ... ... (E) Nov. 1894
Maslen, Frank E., 14, Belsize Park Gardens, Hampstead, London, N.W. ... ... (E) Nov. 1891

ELECTED.

Mather, Clifford B. ... ... (S) Oct. 1892
McCoull, Cecil, Ovington House, Ovingham, R.S.O., Northumberland .. .. (E) Oct. 1895
McIlwraith, Charles H. C., 5, Kayll Road, Sunderland ... ... (E) Nov. 1895
McKenna, Francis, 46, Hodgson Street, Willington Quay-on-Tyne (E) Dec. 1890
McRae, Thomas, Alexandra Terrace, Govan, Glasgow ... ... (S) Oct. 1895
McRobie, Frank, 25, Victoria Street, Newcastle-on-Tyne ... ... (E) Mar. 1889
Mellanby, Alexander L., Fernleigh, Grange Road, West Hartlepool (E) Dec. 1894
Moroney, Edward F., 180, Gloucester Road, Newcastle-on-Tyne... (E) Feb. 1892
Mould, Francis, 36, Salter's Road, Gosforth, Newcastle-on-Tyne... (E) Feb. 1892

N.

Nichol, Bryce Gray, 37, Grove Street, Newcastle-on-Tyne... ... (E) Oct. 1891
Nicholson, James Henry, 30, Azalea Terrace South, Sunderland ... (E) Mar. 1892

O.

Olsen, Hans B., Jun., Wellington Road, West Hartlepool... ... (E) Feb. 1895

P.

Palmer, Henry G., 12, Havelock Street, Newcastle-on-Tyne ... (E E) Dec. 1894
Pashby, Arthur, 10, Campbell Street, Newcastle-on-Tyne ... ... (E) Nov. 1895
Patterson, Robt. O., Thorneyholme, Blaydon-on-Tyne ... ... (E) Jan. 1895
Pearson, James, 10, Beech Grove Road, Newcastle-on-Tyne ... (S) Nov. 1893
Phillips, John Frederick, c/o Mrs. Coulson, King Street, East Hartlepool ... ... (E) Oct. 1892
Posgate, James Stephen, 18, North View, Heaton, Newcastle-on-Tyne... ... ... (E) Nov. 1895
Purvis, Herbert T., 5, Graingerville, Newcastle-on-Tyne ... ... (E) Oct. 1894

R.

Raincock, Walter, c/o Mrs. Ewart, 8, Washington Terrace, North Shields ... ... (N A) Dec. 1893
Rappoport, Fred. G., 58, Holly Avenue, Jesmond, Newcastle-on-Tyne (E) Mar. 1894
Reid, John Robert, 88, Leslie Terrace, Aberdeen ... ... (E) Nov. 1892
Rickaby, Augustine, Bloomfield Engine Works, Monkwearmouth, Sunderland ... ... (E) Nov. 1885
Robinson, Charles O., Ingleside, North Shields ... ... (E) Dec. 1893
Robson, Nathaniel E., 11, Point Pleasant Terrace, Wallsend-on-Tyne... ... ... (E) Dec. 1894
Robson, Robert, 166, Rye Hill, Newcastle-on-Tyne... ... ... (E E) Dec. 1894
Ross, William Daniel, 22, Archbold Terrace, Jesmond, Newcastle-on-Tyne ... ... (E) Feb. 1896

S.

Scott, Alex. C., Malvern House, Edward's Road, Whitley, Newcastle-on-Tyne ... ... (E) Jan. 1895
Scott, Joseph, 49, Leazes Terrace, Newcastle-on-Tyne ... ... (E) Dec. 1891
Scott, W. A., 100, George Road, Newcastle-on-Tyne ... ... (E E) Oct. 1894

ELECTED.

Shand, William Lamont, 39, Holly Avenue, Newcastle-on-Tyne ... (E) Nov. 1895
Short, Thomas Smart, c/o Messrs. Short Brothers, Pallion, Sunderland... ... ... (S) Oct. 1892
Smith, William S., West Villa, The Green, Wallsend-on-Tyne ... (S) Dec. 1893
Spencer, Harry John, 3, Victoria Street, Newcastle-on-Tyne ... (E) Dec. 1892
Squire, Charles E., Arnside House, Grosvenor Road, Newcastle-on-Tyne... ... ... (E E) Nov. 1893
Stephens, Henry C. J., 94, Fortress Road, London, N.W. ... ... (E) Oct. 1890
Stephenson, Robert, c/o Messrs. Robt. Stephenson & Co., Limited, South Street, Newcastle-on-Tyne ... ... (E) Mar. 1894
Stuart, John, 57, Heaton Park Road, Newcastle-on-Tyne ... ... (E) Dec. 1895
Summerson, Benjamin, Dene Crescent, Walker-on-Tyne, R.S.O. ... (E) Dec. 1892

T.

Thomas, Robert Gates, 169, Coatsworth Road, Gateshead-on-Tyne (E) Nov. 1894
Thomas, William, 3, Chester Crescent, Newcastle-on-Tyne ... (E) Oct. 1895
Townend, Sidney, 3, St. Eleanor Street, Cullercoats ... ... (E) Nov. 1895
Turner, Charles N., 2, Newburn Lane, Newburn-on-Tyne... ... (E) April 1896
Tweddell, G. H., 18, Archbold Terrace, Newcastle-on-Tyne .. (E E) May 1894

V.

Vardy, George, Neptune Engine Works, Walker-on-Tyne... ... (E) Oct. 1894
Varty, B. S., 16, Hawthorn Street, Newcastle-on-Tyne ... ... (S) Oct. 1895

W.

Walker, Gavin Knox, 87, Jesmond Road, Newcastle-on-Tyne ... (E) Mar. 1894
Warburton, John A., 9, Foyle Street, Sunderland ... ... (E) Mar. 1894
Ward, Joseph P., c/o Messrs. John Spencer & Co., Newburn Steel Works, Newburn-on-Tyne ... ... (E) Oct. 1895
Wawn, T. Noel, 6, Belle Vue, Sunderland ... ... (E) Nov. 1893
Wildridge, Richard, 7, Alexandra Crescent, Newcastle-on-Tyne ... (E) Oct. 1895
Wilkin, Ernest Vivian, 11, Appold Street, Finsbury, London, E.C. (E) Nov. 1892
Willcox, Reginald J. N., The Oaks West, Sunderland ... ... (E) Mar. 1892
Wilson, John R. S., Roseworth Tower, Gosforth, Newcastle-on-Tyne (E) Mar. 1894
Wilson, Percy P., Bank House, Fawcett Street, Sunderland ... (S) Jan. 1896
Wright, George Hudson, 35, Washington Terrace, North Shields... (E E) Feb. 1896
Wood, John Scott, 6, Eslington Terrace, Newcastle-on-Tyne ... (S) Oct. 1891
Wyand, Fred. W., 13, Eldon Street, Newcastle-on-Tyne ... ... (E E) Oct. 1894

THE NORTH-EAST COAST INSTITUTION

OF

ENGINEERS AND SHIPBUILDERS.

Constitution and Bye-Laws,

ADOPTED AT A GENERAL MEETING ON THE 4TH MARCH, 1885.

REVISED AT THE CLOSING BUSINESS MEETING HELD ON MAY 4TH, 1887.

RE-REVISED AT THE CLOSING BUSINESS MEETINGS HELD ON MAY 9TH, 1888, MAY 13TH, 1889, MAY 11TH, 1891, AND MAY 14TH, 1895.

CONSTITUTION.

I.—The NAME of the Association is "The North-East Coast Institution of Engineers and Shipbuilders." Name

II.—The OBJECTS for which the Institution is established are:—The advancement of the science and practice of Engineering and Shipbuilding, and the interchange of ideas and information amongst its members, by means of meetings for the reading and discussion of papers relating thereto, and placing on record its transactions. Objects.

III.—The Institution shall consist of Honorary Members, Members, Associates, and Graduates.

IV.—HONORARY MEMBERS shall be such distinguished persons as the Council may elect. Honorary Members.

V.—MEMBERS shall be Principals or Principal Managers engaged in Engineering or Shipbuilding; Civil, Military, or Mining Engineers, or Naval Architects; whose subscription shall be Two Guineas per annum: and other persons engaged in the above professions; whose subscription shall be One Guinea per annum. Members.

VI.—ASSOCIATES shall be such persons as are not strictly Engineers or Shipbuilders, but are connected with or interested in such pursuits, and are deemed by the Council to be eligible for Associate membership. Their subscription shall be One Guinea per annum. Associates.

Graduates.

VII.—GRADUATES may be persons under twenty-four years of age, engaged in study or employment to qualify themselves for any of the above professions. Their subscription shall be Half-a-Guinea per annum.

Life Members and Associates.

VIII.—Any MEMBER may become a LIFE MEMBER by a single payment of Twenty Guineas, or any ASSOCIATE may become a LIFE ASSOCIATE by a single payment of Ten Guineas. All such compositions shall be deemed to be capital moneys of the Institution.

Officers.

IX.—The COUNCIL of the Institution shall be elected from and by the Members, and shall consist of one President, the Past-Presidents, nine Vice-Presidents, fifteen Ordinary Members of Council, and an Honorary Treasurer.

Election of Officers. (See Bye-Law No. 11.)

X.—The President and Honorary Treasurer shall be elected annually. Three Vice-Presidents and five Ordinary Members of Council shall be elected annually. The retiring Vice-Presidents and Ordinary Members of Council shall be those who have served three years from their last election.

The President shall be eligible for re-election for a second year; should he be re-elected he shall retire at the conclusion of his second year of office, and shall not again be eligible until after an interval of one year.

The retiring Vice-Presidents shall be eligible for re-election. The retiring Ordinary Members of Council shall not be eligible for re-election to the same office until after an interval of one year, but shall be eligible for election to any other office.

The Honorary Treasurer shall be eligible for re-election annually, or for election to any other office.

Honorary Members' Privileges.

XI.—Honorary Members may attend all the General Meetings, they may read papers, take part in discussions, in voting, in moving and supporting resolutions, in presentation of notices of motion, or in requisitions for Special Meetings, and in the proposition of new members; they shall also receive copies of the Transactions.

Members' Privileges.

XII.—Members shall have all the privileges of the Institution as enumerated in the foregoing paragraph, and shall be eligible for office.

Associates' Privileges.

XIII.—Associates shall have all the privileges enumerated in paragraph XI. They shall be eligible for office as Ordinary Members of Council.

XIV.—Graduates may attend all the General Meetings, they may read papers, take part in discussions, and support resolutions; they shall also receive copies of the Transactions, but shall not sign proposals for new members, vote, nor be eligible for office. Graduates' Privileges.

XV.—The General Meetings of the Institution shall be held during the months of October to May, inclusive, of each year. General Meetings.

NOTE.—When the word Member is initialled with a capital letter it signifies a member under paragraphs IV. and V., but when initialled with a small letter, it signifies a member of any class of the Institution membership.

BYE-LAWS.

MEMBERSHIP.

1.—Every candidate for admission as a Member, Associate, or Graduate shall be proposed and recommended according to the Form A in the Appendix, in which form the name, usual residence or the place of business, the qualification for, and proposed class of membership of the candidate shall be distinctly specified. Proposals for Graduates must give the date of, and age, last birthday. Candidates for Admission.

The form shall be signed by a Member or Associate of the Institution, as proposer, and by at least other three Members or Associates as supporters, certifying a personal knowledge of the candidate.

The proposal so made shall be submitted to the Council, when, if it be approved, the Chairman shall sign the approbation, which shall be inserted in the notice calling the next General Meeting, when the candidate shall be balloted for, and shall be accepted if three-fourths of the votes are favourable.

2.—Graduates desirous of becoming Members shall be proposed and recommended according to the Form B in the Appendix. Graduates becoming Members.

The proposal so made shall be submitted to the Council, who shall agree to or reject it.

3.—The balloting for membership shall be conducted in the following manner:—Each member shall be supplied by post with a list of the names of the candidates, according to the Form C in the Appendix, and shall strike out the names of such candidates as he desires shall not be elected. These lists may be Balloting for Members.

returned to the Secretary by post, or may be deposited in the ballot-box by the voter in person on entering a meeting at which an election is to take place. The ballot-box will be closed at ten minutes after the advertised time of meeting. The lists shall then be handed over to the Chairman, who shall appoint two Scrutineers to examine them, after which examination the Chairman shall inform the meeting of the result.

Candidates to receive Notice of Election.

4.—Notice of Election as a member shall be sent to the candidate within one week after his election, according to the Form D in the Appendix; but his name shall not be added to the list of Members, Associates, or Graduates of the Institution, until he shall have paid his first annual subscription.

Rejection of Candidates.

5.—In case of rejection of the candidate, no mention thereof shall be made in the minutes, nor shall any notice be given to the unsuccessful candidate.

Subscriptions payable in Advance.

6.—All subscriptions shall be payable in advance, and shall become due on the 1st of August each year. Any Member, Associate, or Graduate, wishing to retire from the Institution shall continue to be liable for his annual subscription until he shall have given formal notice of his retirement to the Secretary, which notice must be given on or before the 31st of August in each year. Application for membership may be made at any time during a Session, and the subscription shall cover the membership up to the 1st of August following.

Receipt of Subscription

7.—On payment of each subscription the Secretary shall forward to the member an official receipt.

Questions of Privilege.

8.—On question of privilege.—Any person who may be unknown in the meeting shall only be able to claim the privilege in question on proving his membership for the current Session.

Arrears of Subscriptions.

9.—Any member whose subscription is one year in arrear shall be reported to the Council, who shall direct application to be made for it, according to Form E in the Appendix; and in the event of its continuing in arrear until the end of that Session after such application, the Council shall have the power, after remonstrance by letter, according to the Form F in the Appendix, of declaring that the defaulter has ceased to be a member.

Power of Council to remove Name from List of members.

10.—The Council may refuse to continue to receive the subscriptions of any member who shall have wittingly acted in contravention of the Regulations of the Institution, or who shall,

in the opinion of the Council, have been guilty of such conduct as shall have rendered him unfit to continue his membership; and the Council may remove his name from the list of members: and such person shall thereupon cease to be a member of the Institution. Notice of such action of the Council shall be forwarded to the person in question, in accordance with the Form G in the Appendix. The reason for such action of the Council shall not be stated to the person expelled, without the sanction of the Council.

OFFICERS.

Election of Officers.

11.—The Annual Election of Officers shall be conducted in the following manner:—The Council shall meet in March or April, and shall arrange a list of nominations, in accordance with the Form H in the Appendix. It shall nominate new names in the place of the retiring Members, and the number of nominations shall be one in excess of the number required in each section of the Council. Such list shall be presented at the General Meeting immediately preceding the last General Meeting of the Session, and any Member present shall be at liberty to nominate additional Members. The list shall show who remain in office throughout the Council, and who are retiring. A copy of this ballot list shall be forwarded to each Member and Associate, together with a complete list of Members of Council, to be filled in and returned to the Secretary in accordance with the instructions printed in the ballot form, to be opened in the presence of the Council, at a Council Meeting which shall be held in April or May, when the scrutiny and counting shall be carried out by the Council. Any Member in voting shall be at liberty to erase any name or names from the list and substitute the names of any other person or persons eligible for each respective office other than those already placed on the ballot list by the Council and Members of the Institution.

Any voting paper returning either more or less than one President, nine Vice-Presidents, one Honorary Treasurer, and fifteen Ordinary Members of Council, shall be disqualified for the section or sections in which such errors occur, and the votes shall be lost for the said section or sections. The votes given as President, to a Member who is not elected President, shall count to him as a Vice-President; the votes given as Vice-President, or Treasurer, to persons not so elected, shall count to

them as Ordinary Members of Council, unless they have just completed a term of office in such capacity.

The voting list shall not be sent to any Member and Associate whose subscriptions are more than one year in arrear; nor shall any Member be nominated on the list. For this purpose, the Secretary shall prepare, previously to the meeting of Council, a list of those Members whose subscriptions are more than one year in arrears.

llot to be clared at May eting.

12.—The result of the ballot for Officers shall be declared at the Closing Business Meeting, to be held in May, at which meeting general business shall be transacted. At this meeting the newly-elected Officers, after being declared, shall enter into office; and this shall be the last meeting of the Session.

wer of Council fill up Casual cancy.

13.—The Council shall have power to supply any casual vacancy within itself (including any casual vacancy in the office of President), which shall occur between one May Meeting and another; and the Officers so appointed shall retire when the person whose place they fill would have retired. Vacancies not filled up during the year shall be filled at the General Election.

GENERAL MEETINGS.

neral etings.

14.—The Annual General Meeting shall take place in October, and the Closing Business Meeting in May; each of these meetings shall be held in Newcastle-upon-Tyne. The Ordinary Meetings shall take place in the second week in each following month during the Session, unless otherwise arranged by the Council, and at such hours and places as the Council may determine.

otice of etings.

15.—Seven clear days' notice of every General Meeting, Ordinary or Special, specifying the nature of business to be transacted, shall be given to every member of the Institution.

ecial General etings.

16.—A Special General Meeting may be convened at any time by the Council, and such meeting shall be convened by the Council whenever such is the declared wish of a General Meeting, or whenever a written requisition, signed by twenty members, specifying the object of the meeting, is left with the Secretary. If, for fourteen days after the delivery of such requisition, a meeting be not convened in accordance therewith, the requisitionists, or any twenty members of the Institution, may convene a Special Meeting in accordance with the requisition. The business discussed at such Special Meetings shall only be that indicated on the notice calling the meeting.

17.—Twenty Members shall constitute a quorum for the purpose of a meeting other than a Special Meeting. Thirty Members shall constitute a quorum for the purpose of a Special Meeting. Quorum.

18.—The President shall be chairman at every meeting, and in his absence, one of the Past-Presidents or one of the Vice-Presidents; or in the absence of these, an Ordinary Member of Council shall take the chair; or if no Member of Council be present and willing to take the chair, the meeting shall elect a Chairman. Chairman at Meetings.

19.—The decision of a General Meeting shall be ascertained by a show of hands; or, when five Members or Associates shall demand, or the Chairman may think it desirable, the decision shall be taken by ballot. The manner of counting the votes shall be at the discretion of the Chairman, and an entry in the minutes, signed by the Chairman, shall be deemed sufficient evidence of the decision of a General Meeting. In cases of equality of votes, the Chairman shall have a casting vote; otherwise he shall not vote. Decisions of General Meetings.

20.—Questions of a personal nature arising in a General Meeting, shall, if possible, be referred to the Council, otherwise the decision of the meeting shall be taken by ballot on a motion or amendment put to the meeting. The ballot shall be taken by the voters (being Members or Associates) writing "for" and "against" on a slip of paper. The slips shall be folded and collected, and then counted in the presence of the meeting, and the result announced by the Chairman. Should fewer than twenty votes be given, it shall be understood that the question is shelved, and the votes shall be destroyed without being opened. Questions of a Personal Nature in General Meetings.

21.—At every General Meeting of the Institution, the Secretary shall first read the minutes of the preceding meeting, which, on approval, shall be signed by the Chairman; business arising out of these minutes shall then be transacted. The Secretary shall read any notices which may have to be brought before the meeting. Notices of motion may then be given, and other business of the Institution may be attended to; but when a paper is to be read, the foregoing business shall not be extended beyond half-an-hour after the advertised time for commencing the meeting. The paper or papers for the evening shall then be read and discussed. Transactions of Business General Meetings.

22.—If within half-an-hour after the time fixed for holding a General Meeting a quorum is not present, the meeting shall be Dissolving a General Meeting.

dissolved, and all matters which might, if a quorum had been present, have been done at the meeting so dissolved, may forthwith be done on behalf of the meeting, by the Council; except the reading or discussion of a paper, which shall not proceed in the absence of a quorum.

Adjourning a General Meeting

23.—Any General Meeting of the Institution may be adjourned by a vote of the Members and Associates present if there be a quorum; if there be not a quorum, the case shall be met by the preceding paragraph.

Introduction of Friends.

24.—Each member shall have the privilege of introducing one friend to the General Meetings, whose name must be written in the Visitors' Book, together with that of the member introducing him; but if the introducing member be unable to attend the meeting, he may send the name of the visitor to the Secretary. During such portions of any of these meetings as may be devoted to any business connected with the management of the Institution, visitors may be requested by the Chairman to withdraw. This shall be done if five Members or Associates, or both, present request it.

COUNCIL MEETINGS.

Council Meetings.

25.—The Council shall meet before each General Meeting, or on other occasions when the President shall deem it necessary; being summoned in either case by circular, stating the time of meeting, and the business, so far as is known.

Convening Meeting for Expenditure of Funds.

No business involving expenditure of the funds of the Institution (except by way of payment of current accounts) shall be transacted at any Council Meeting, unless the circular gives six clear days' notice, and states the business.

Discussions of Personal Character.

All discussions of a personal character in the Council shall be considered and treated as being strictly confidential.

Regulation of Proceedings.

26.—The Council may regulate its own procedure, and delegate any of its powers and discretions to any one or more of its number.

Chairman and Quorum.

The President shall, *ex-officio*, be chairman of all Council Meetings, and in his absence one of the Past-Presidents or one of the Vice-Presidents shall take the chair; or in the absence of these, one of the Ordinary Members of Council shall be elected to take the chair. Five members of Council, including the Chairman, shall form a quorum.

Sub-Committees.

In the appointment of Sub-Committees, the Council shall determine the number which shall form a quorum in each case,

and shall appoint a Chairman. These regulations shall not affect the Finance Committee.

27.—The Council may appoint Committees either from itself, or with the assistance of persons outside, for the purpose of transacting any special business, or of investigating specific objects connected with the work and interests of the Institution. Sub-Committees.

28.—All Committees or Sub-Committees shall be appointed by the Council, and shall be subject to that body, and shall report to it. The Council shall act upon these reports or recommendations as it may think best. The President shall, *ex-officio*, be a member of all Committees. Sub-Committees.

29.—Any member may by communication addressed to the Secretary petition the Council to lay before a General Meeting of the Institution the contents of any letter which shall in a short, concise, and clear manner draw the attention of the Institution to public matters of importance in connection with legislation proposed by any governing body in reference to the construction of ships, machinery, or the working of the same, so that members may by their scientific and practical knowledge demonstrate the soundness or otherwise of the proposed measure. Communication to Council.

30.—The Council may invite to General Meetings or to Council Meetings any person or persons whose presence and assistance it may desire, and strangers so invited shall be permitted to take part in the proceedings, but not to vote. Invitation to Strangers.

31.—The Secretary, who shall also act as Treasurer, shall be appointed by and act under the direction and control of the Council, and shall be paid such salary as the Council shall determine. He shall attend all meetings, Council and General, and shall take minutes of the proceedings, and enter them in proper books provided for the purpose. He shall write the correspondence of the Institution and Council, read minutes and notices at meetings, report discussions, and, if required by the Council, prepare papers for reading and publication, and read papers and communications at the meetings. He shall receive all payments due to the Institution, and shall bank the cash in hand whenever it amounts to ten pounds. The bank shall be determined by the Council and the banking account shall be in the names indicated in connection with the Finance Committee. He shall keep a cash account book, general and detail, which shall on all occasions be open to inspection by the Finance Secretary and Treasurer's Duties.

Committee or by the Council. He shall keep a register of the names of members, so arranged as to distinguish all members whose subscriptions are in arrear. He shall also perform whatever other duties are indicated in the Bye-Laws of the Institution as appertaining to his department; and shall remain in office during the pleasure of the Council. He shall not vote on any resolution.

32.—The following Sub-Committees shall be appointed annually at the first meeting of the Council in each Session:—

Finance Committee.

(1) A Finance Committee, to consist of seven persons, viz.: one Past-President or Vice-President, who shall be Chairman; five Members of Council, and the Honorary Treasurer of the Institution; three of whom shall form a quorum. The Treasurer shall be empowered to pay all amounts due from the Institution which are under two pounds. All amounts of two pounds and upwards shall be paid by cheque, signed by the Chairman of the Finance Committee (or in his absence, by the President or a Past-President), the Secretary and the Honorary Treasurer. (2) A Reading Committee, to consist of six members of Council. No member who has served on this Committee for three years in succession shall be eligible for re-election until after an interval of one year. (3) A Library Committee, in accordance with Library Rules, Nos. 1 and 3. (4) A Graduates' Award Committee to consist of five members.

Payment of Accounts.

Reading and Library Committees.

TRANSACTIONS.

Papers to be submitted to Council.

33.—All papers shall be forwarded to the Secretary at least five clear weeks before the proposed date of reading. The Secretary shall submit them for approval to the Council, and on their general approval they shall be handed to the Reading Sub-Committee, three of whom at least, shall read the paper through. The Reading Sub-Committee shall be at liberty to strike out any parts which, in their opinion, ought not to be read. They may also make any suggestions to the author as to points which might with advantage be inserted or altered.

Reading Sub-Committee.

Printing Transactions.

34.—The papers read, and the discussions on them, or such portions of them as the Council shall select, shall be printed for distribution among the members, each of whom shall receive a copy. These Transactions shall be edited by the Secretary, in accordance with instructions of the Council, who shall have

power to omit parts of discussion which may be foreign to the subject, or which it may be deemed inadvisable to retain. Each paper shall bear the date on which it was read at General Meeting.

Copy of Papers required to be sent before reading, etc.

35.—Copies of papers to be read during any Session will be sent seven days before the time of reading to members who shall have applied to the Secretary for them, in writing, at the commencement of the Session. The discussion on a paper shall not be considered closed on the evening on which it is read, but shall be open for renewal at a subsequent meeting, prior to the reading of the paper set down for that time.

Proofs sent to Speakers for Correction.

36.—The Secretary shall send to each speaker as soon as possible after a General Meeting a copy in manuscript of the speaker's own remarks for correction. This copy must be returned to the Secretary within four days. A printed proof will also be sent to each speaker for further revision: this must be returned to the Secretary within three days, otherwise it will be deemed correct, and printed off after receiving verbal corrections.

Liberty to Print Explanatory Notes.

37.—The Council shall be at liberty to print as Transactions, either with the papers and discussions or separately, explanatory notes, etc., communicated after the reading or discussing of a paper. Such communications must be approved by the Reading Committee, and shall bear the date on which they shall have been received by the Secretary.

Institution not responsible for statements.

38.—The Institution shall not be held responsible for the statements and opinions advanced in any of the papers which may be read, or in the discussions which may take place at the Meetings of the Institution.

Copies of Transactions to be sent to members.

39.—Twenty copies of each paper and discussion shall be presented to the author of the paper, for private use, and one copy shall be sent to each member. When a paper is prepared by two authors, fifteen copies shall be presented to each. Duplicate copies of parts of the Transactions mislaid or lost by members cannot be supplied to them, except as provided for in Bye-Law 42.

Transactions not supplied to members in Arrears.

40.—The Transactions shall not be supplied free to members whose subscriptions are more than one year in arrear.

Members not to receive Transactions till after First Payment.

41.—Any member elected at any time between the Annual General Meetings shall be entitled to copies of all the Transactions issued during the Session to which his first subscription applies; but not until the subscription has been paid.

Transactions the Property of the Institution.

42.—The Transactions of the Institution shall be the exclusive property of the Institution, and shall be published only by the authority of the Council. Additional copies of papers required by authors for their private use can only be procured from the Secretary, at prices fixed by the Council from time to time, and these copies must contain the whole of the discussion following the papers, and be bound in the usual cover, with the addition of the following words:—"By permission of the Council," and "Excerpt Minutes of Proceedings." Duplicate volumes and copies of parts of the Transactions, if in print, can also be obtained from the Secretary, and shall be sold only by him, in such manner and at such prices as the Council shall have fixed.

Rule of Discussion.

43.—During a discussion upon any paper, no person shall be at liberty to speak more than once (except by way of explanation), nor for a longer period than ten minutes.

ACCOUNTS, &c.

Accounts.

44.—The Council shall present the yearly accounts (up to the 31st of July preceding) at the Annual General Meeting in October of each year, after they have been audited by a professional Accountant, appointed by the members at the Closing Business Meeting in May.

Trustees.

45.—The capital, stock, and funds of the Institution shall be vested in the names of three Trustees, to be elected from time to time as vacancies occur by the members of the Institution at a General Meeting called for that purpose. All mortgages and other securities shall be taken in the names of such Trustees; and on any new appointment the funds shall vest in the newly-appointed Trustee or Trustees jointly with the continuing or remaining Trustee or Trustees.

Investment of Funds.

46.—The Finance Committee may, with the consent of the Council, invest in the names of the appointed Trustees of the Institution any moneys not immediately required for the purposes of the Institution, in or upon any approved securities.

ALTERATIONS TO CONSTITUTION AND BYE-LAWS.

47.—Alteration in or addition to the Constitution and Bye-Laws may be made only by resolution of the members at the

Closing Business Meeting in May, after notice of the proposed alteration or addition has been announced at the previous General Meeting.

The resolution may be modified by the Council meanwhile, should they so desire; but in this case it shall be read at the Closing Business Meeting in May in its original form before it is proposed in the amended form.

Such resolutions shall be stated in the notice calling the intervening Council Meeting, and also in the notice calling the Closing Business Meeting in May.

Vote by Proxy.

Any member unable to be present at the meeting at which such alterations are to be considered, but who is nevertheless desirous of recording his opinion thereon, shall be allowed to vote by proxy, such proxies shall be in Form J in the Appendix, which may be had on application to the Secretary, and may be used by any member present at the meeting on behalf of the absent member, and counted by the Chairman as of equal value with votes given in the manner provided in Bye-Law 19.

THE LIBRARY AND READING ROOM RULES.

Committee.

1.—The Library and Reading Room shall be managed by a Committee, called the Library Committee, who shall have charge of all books, papers, specimens, etc., which may belong to the Institution. It shall consist of five members of the Institution, of whom at least two shall be members of Council.

Property.

2.—The books and other property of the Library shall be vested in the Trustees appointed by the Institution.

Appointment of Committee.

3.—The Library Committee shall be appointed annually, at the first meeting of the Council in each Session. No member who has served on the Committee for three years in succession shall be eligible for re-election until after an interval of one year. The Chairman shall be elected by the Council.

Librarian.

4.—The Secretary of the Institution shall be Librarian, and shall also act as Secretary to the Library Committee. Three members of the Committee shall form a quorum.

Duties of Committee.

5.—The Library Committee shall be responsible for the binding and purchasing of books, periodicals, papers, etc., and for the expending of all money voted by the Council for its use. It shall appoint an attendant who shall act as Assistant

Librarian. It shall make Rules for the management of the Library, subject to the approval of the Council, and present an annual report to the first meeting of the Council held after the annual scrutiny of the books referred to in Rule No. 13.

Hours of Opening and Closing, etc

6.—Except when closed by special order of the Library Committee, or when the Council is sitting, the Library and Reading Room shall be open for consulting, borrowing, or returning books, every week day as follows:—On Monday, Tuesday, Wednesday, and Friday, from 10 a.m. to 12 noon, and from 1 to 9 p.m.; on Thursday, from 10 a.m. to 12 noon, and from 1 to 5 p.m.; on Saturday, from 10 a.m. to 1 p.m., and from 2·30 to 9 p.m. The Rooms will be closed on Christmas Day and the day following, New Year's Day and the day following, Good Friday, Monday and Tuesday in Easter week and Whit week, and the first Monday in August (being Bank Holiday); also at noon on Tuesday, Wednesday, Thursday and Friday in the Race week of June, and from the second to the fourth Saturday in July of each year, as mentioned in Rule No. 13.

Lending of Books.

7.—Books shall not be lent to any persons except Members, Associates, or Graduates of the Institution, but a person entitled to borrow a book may send a messenger with a signed order for it.

Visitors.

8.—Each member shall be entitled to introduce a friend to the Reading Room, whose name shall be written in the Visitors' Book, together with that of the member introducing him.

Reference Books.

9.—The books marked with an asterisk in the Catalogue shall be kept only for consultation in the Library, and shall not be lent. Pending the preparation of a Catalogue, the Librarian shall be instructed by the Committee as to which books shall be withheld from circulation.

Unbound Books.

No periodicals, magazines, or pamphlets shall be issued for circulation until after they have been bound and added to the Lending Library.

Register of Books Lent, etc.

10.—The Librarian shall keep a register in which he himself or the attendant shall enter the titles of the books lent, the date of lending, the name of the borrower, and the date of the return of the book to the Library. The borrower of the book or the bearer of his order shall initial the entry of such borrowing, and the Librarian or the attendant shall initial the date of the return of the book.

11.—No person shall borrow or have in his possession at one time more than two volumes belonging to the Library. Number Lent to each member.

12.—No member shall retain a book longer than fourteen days, excluding the day of issue. He shall be responsible for the safe return of the book, and if it be damaged or lost he shall make good the cost of such damage or loss. Return of Books.

13.—All books belonging to the Library shall be called in for inspection, and the lending out of books shall be suspended from the second to the fourth Saturday of July, inclusive, of each year, and members shall be required by notice to return all books in their hands before the period mentioned. Yearly Inspection of Books.

Members failing to comply with this injunction shall pay a fine of two shillings and sixpence. Fine.

14.—Members are requested, when in the Reading Room or Library, to contribute to the general comfort by carefully abstaining from loud talking and noise of any kind. Smoking is not permitted in the Library.

15.—Any member being twelve months in arrears with his subscriptions to the Institution shall not be at liberty to use the Library or Reading Room after the commencement of the first Session following. Members in Arrears.

N.B.—The foregoing Rules may be amended at any time by the Library Committee with the sanction of the Council.

APPENDIX TO BYE-LAWS.

FORM A. (BYE-LAW 1.)

Name (in full)
Profession or Occupation and where Employed
Address
being desirous of admission into the North-East Coast Institution of Engineers and Shipbuilders, we, the undersigned, propose and recommend that he shall become*
thereof. We know him to be†
and eligible for the proposed membership.

* A Member, Associate, or Graduate.

† A Principal, Manager, or Draughtsman, etc. See Articles V., VI., and VII. of Constitution.

	FROM PERSONAL KNOWLEDGE.	SECTION OF MEMBERSHIP.
Proposed by	_____	_____
Supported by Three Members or Associates.	_____	_____
	_____	_____
	_____	_____

Dated this day of

(*When a Graduate is proposed the age last birthday should be stated.*)

FORM B. (BYE-LAW 2.)

A. B. [Christian Name, Surname, Occupation, and Address in full] being at present a of the North-East Coast Institution of Engineers and Shipbuilders, and upwards of twenty-four years of age, and being desirous of becoming a of the said Institute, we, the undersigned [Members or Associates], recommend him, from *personal knowledge*, as a person eligible for the proposed Change of membership, because—

(*Here specify distinctly the Qualifications of the Candidate according to the spirit of the Rules of the Institution.*)

Signed _____ } Three [Members or Associates.]
_____

Dated this day of 18

FORM C. (BYE-LAW 3.)

BALLOTING PAPER FOR MEMBERSHIP.

The Council having considered the recommendations for Membership of the following gentlemen, present them to be balloted for, viz.:—

Member, Associate, or Graduate.	Occupation.	Address.	Nominated by.	Supported by Three Members or Associates.

Strike out the names of such persons as you desire shall *not* be elected, and forward the list by post to the Secretary, or personally place it in the ballot-box at the Meeting.

FORM D. (BYE-LAW 4.)

Sir,—I am directed to inform you that on the day of you were elected a of the North-East Coast Institution of Engineers and Shipbuilders, but, in conformity with Bye-Law 4, your election cannot be confirmed, nor your name be added to the roll of membership, until you have paid your first annual subscription, the amount of which is £ : : , or, at your option, the Life Composition of £ : : .

Payment may be made to the Treasurer, Mr._____

Address_____

I am, Sir,

Yours faithfully,

Secretary.

Dated 18

N.B.—In case of a Graduate, strike out "*or, at your option, the Life Composition of* £ : : "

FORM E. (BYE-LAW 9.)

SIR,—I am directed by the Council of the North-East Coast Institution of Engineers and Shipbuilders to draw your attention to Bye-Law 6, and to remind you that the sum of £ of your annual subscriptions remains unpaid, and that you are in consequence in arrear of subscription.

I am also directed to request that you will cause the same to be paid without further delay, otherwise the Council will be under the necessity of exercising their discretion as to using the power vested in them by the Rule above referred to.

I am, Sir,

Yours faithfully,

Secretary.

FORM F. (BYE-LAW 9.)

SIR,—I am directed by the Council of the North-East Coast Institution of Engineers and Shipbuilders to inform you that in consequence of non-payment of your arrears of subscription, and in pursuance of Bye-Law 9, the Council have determined that unless payment of the amount (£) is made previous to the day of next, they will proceed to declare that you have ceased to be a member of the Institution.

But, notwithstanding this declaration, you will remain liable for payment of the arrears due from you.

I am, Sir,

Yours faithfully,

Secretary.

FORM G. (BYE-LAW 10.)

SIR,—I am directed by the Council of the North-East Coast Institution of Engineers and Shipbuilders to inform you that they feel it their duty to advise you to withdraw from the Institution, or otherwise they will be obliged to act in accordance with Bye-Law 9 (or 10, as the case may be).

I am, Sir,

Yours faithfully,

Secretary.

FORM H. (BYE-LAW 11.)

BALLOTING LIST.

PRESIDENT.—ONE NAME only to be returned, or the vote will be lost.

——— President for the current year (eligible for re-election.)*

——— ———
——— } New Nominations, from whom to select ONE.

VICE-PRESIDENTS.—NINE NAMES only to be returned (including the six who remain in office), or the vote will be lost.

——— ———
——— } Six Vice-Presidents remaining in office, whose seats are NOT vacant.

——— ———
——— } Three Vice-Presidents retiring, eligible for re-election.

——— ———
——— } New Nominations, from whom to select THREE names.

TREASURER.—ONE NAME only to be returned, or the vote will be lost.

——— Treasurer for the current year, eligible for re-election.

——— ———
——— } New Nominations, from whom to select ONE.

ORDINARY MEMBERS OF COUNCIL.—FIFTEEN NAMES only to be returned, including the ten who remain in office.

——— ———
——— } Ten Ordinary Members of Council remaining in office. These do not require to be voted for at this election, as their term of service has NOT yet expired.

——— ———
——— } Five Ordinary Members of Council retiring, and NOT eligible for re-election.

——— ———
——— } New Nominations, from whom to select FIVE.

* To be crossed out before issue, when the President is not eligible for re-election.

N.B.—(*a*) The names of those who remain in office will be counted in the total number required without being re-written by the voter.

(*b*) Any list having either MORE or LESS than the required number of names voted for in any section will be disqualified for that section.

(*c*) Votes as President for a person who is not elected will count for him as a Vice-President.

(*d*) Votes as Vice-President, or Treasurer, for persons not so elected, will count for them as Ordinary Members of Council, unless they have just completed a term of office in that capacity.

(*e*) This list, duly filled in, may be returned to the Secretary by post, or handed to him, so as to be on the Council table before the commencement of the scrutiny, which is appointed to take place in the Council Room, at 8 p.m., on 18

(*f*) A copy of this list shall be posted at least Seven Days previous to the Annual Meeting to every Member and Associate, who may erase any name or names from the list and substitute the name or names of any other person or persons eligible for such respective offices, but the number of persons on the list after such erasure or substitution must not exceed the number to be elected to the respective offices.

Secretary.

FORM J. (BYE-LAW 45.)

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

FORM OF PROXY.

FOR VOTES ON ALTERATIONS TO CONSTITUTION OR BYE-LAWS.

I, ..., being [an Honorary Member, Member, or Associate] of the above Institution, do hereby appoint Mr..... who is [an Honorary Member, Member, or Associate] of the same Institution, to act as my Proxy, and record my Vote at the General Meeting of the Institution, to be held on the... .....day of ....., 18....., and at any adjournment thereof.

Signature... .....

Address.....

....

.....*Secretary.*

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

Supplementary Bye-Laws Relating to the Graduate Section.

I.—The Graduate Section shall be controlled by the General Bye-Laws of the Institution, and the following Bye-Laws are supplementary to these.

This Section shall be open to all Members of the Institution who are under twenty-six years of age, who shall be at liberty to express their views upon any subject brought before the General Meetings of the Section.

II.—The Officers of the Section shall be elected from and by the Graduates, in accordance with the Form given in the Appendix, and shall consist of one Chairman, one Honorary Secretary, and five Committee-men. The Committee shall have power to select one of its members to act as Assistant Honorary Secretary if required. **Officers by Ballot.**

III.—(*a*) The Officers shall be elected annually, and shall all be eligible for re-election until the age limit is reached. **Election of Officers.**

(*b*) Any voting paper returning either more or less than one Chairman, one Honorary Secretary, and five Committee-men shall be disqualified. **Rider to General Bye-Law No. 11.**

IV.—The Annual General Meeting shall take place as early as possible after that of the Institution in the month of October, and the Closing Meeting shall be held prior to the Closing Business Meeting of the Institution in May. **General Meetings.**

V.—A Special General Meeting may be convened at any time by the Committee. The business discussed at such Special Meetings shall only be that indicated on the notice calling the meeting. **Special General Meetings.**

VI.—Nine Members shall constitute a quorum for the purpose of a General Meeting. **Quorum.**

VII —Excursions shall be arranged during the Session as the Committee may find expedient. Any Graduate wishing to intro- **Excursions.**

duce a friend at such excursions must submit the name of his friend to the Committee at least three clear days before the date of the excursion.

Seven clear days' notice of every excursion shall be given to every Member of the Graduate Section.

COMMITTEE MEETINGS.

Committee Meetings.

VIII.—The Committee shall meet at as early a date as possible after the holding of a General Meeting, and on other occasions when the Chairman shall deem it necessary, being summoned in either case by circular, stating the time of meeting and the business so far as is known. All discussions of a personal character in the Committee shall be considered and treated as being strictly confidential.

Four members of Committee, including the Chairman, shall form a quorum.

Duties of Hon. Secretary.

IX.—The Honorary Secretary shall act under the direction and control of the Committee. He shall attend all Meetings, Committee and General, and shall take minutes of the proceedings and enter them in proper books provided for the purpose. He shall write the correspondence of the Graduate Section and Committee (excepting that arranging for excursions, which shall be arranged by the Secretary of the Institution). He shall keep a stamp account book, which on all occasions shall be open to the inspection of the Secretary of the Institution.

PAPERS.

Synopsis of Papers to be read.

X.—The author of a paper shall forward to the Honorary Secretary, at least fourteen days before the date of the reading of the paper, its title and a synopsis of the contents; a copy of the synopsis to be forwarded to every Graduate, together with the notice convening the meeting at which the paper is to be read.

Copies of Papers to be forwarded to the Secretary of the Institution.

XI.—After the reading of a paper a copy must be forwarded to the Secretary of the Institution in time to be placed before the Graduate Awards Committee. This copy, if deemed necessary by the Council, shall become the property of the Institution, and be placed upon the shelves in the Library. These copies, together with any sketches accompanying them, shall be written upon paper of uniform size.

APPENDIX.

GRADUATES' BALLOTING LIST.

CHAIRMAN.

*——— (E)
——— ( ) } Nominations from whom to select ONE.

HON. SECRETARY.

*——— (E)
——— ( ) } Nominations from whom to select ONE.

COMMITTEE.

*——— (S)
*——— (EE)
*——— ( )
——— ( )
——— ( )
——— ( ) } Nominations from whom to select FIVE.

NOTES.

1.—Any list having either more or less than the required number of names will be disqualified.

2.—All voting papers must be returned to the Secretary of the Institution on or before the day of , 18 .

3.—No signature must be put on this paper.

4.—* Signifies a member of the old committee.

5.—(E) Denotes Engineer; (EE) Electrical Engineer; (S) Shipbuilder.

6.—A copy of this list shall be posted, at least fourteen days previous to the Closing Meeting of the Session, to every Graduate, who may erase any name or names from the list and substitute the name or names of any other person or persons eligible for such respective offices, but the number of persons on the list after such erasure or substitution must not exceed the number to be elected to the respective offices.

7.—Votes as Chairman or Hon. Secretary, for persons not so elected, will count for them as members of committee.

NORTH-EAST COAST INSTITUTION

OF

ENGINEERS AND SHIPBUILDERS.

TWELFTH SESSION, 1895-96.

PROCEEDINGS.

The twelfth session of the Institution was inaugurated on the evening of the 18th day of October, 1895, by a conversazione and ball at the invitation of the President, Alderman Thomas Richardson, B.A., M.P., in the Assembly Rooms, Westgate Road, Newcastle-upon-Tyne, and was attended by a large assemblage of ladies and gentlemen.

THE FIRST GENERAL MEETING OF THE SESSION, HELD IN THE LECTURE HALL OF THE LITERARY AND PHILOSOPHICAL SOCIETY, NEWCASTLE-UPON-TYNE, ON FRIDAY EVENING, OCTOBER 25TH, 1895.

ROBERT THOMPSON, ESQ., J.P., PAST-PRESIDENT, IN THE CHAIR.

Before proceeding with the business, the PAST-PRESIDENT asked the Secretary to read the following letter from the President :—

KIRKLEVINGTON GRANGE, YARM, YORKSHIRE,

DEAR MR. DUCKITT, *October 24th*, 1895.

I am extremely sorry to inform you that I find that I have an important engagement to-morrow, Friday, the 25th, which will prevent my being present at the meeting. Will you kindly convey to the members of the Institution my extreme regret at my not being able to be present at the first meeting of the present session Mr. Robert Thompson has very kindly promised, if possible, to take my place.

Yours faithfully,

T. RICHARDSON.

The SECRETARY read the minutes of the Closing Meeting of the last session, held in Newcastle-upon-Tyne, on 14th May, 1895, which were approved by the members present and signed by the Past-President.

The ballot for new members having been taken, the Past-President appointed Messrs. A. G. Schaeffer and W. Hök to examine the voting papers, and the following gentlemen were declared elected :—

MEMBERS.

Aisbitt, Matthew Wheldon, Naval Architect, etc., 47, Mount Stuart Square, Cardiff.

Armour, Jas. Glencairn, Ship Surveyor, Bureau Veritas, Custom House Court, Quayside, Newcastle-upon-Tyne.

Armstrong, R. W., Engineer, Dunston Engine Works, near Gateshead-on-Tyne.

Brotherstone, James, Engineer, 8, Whitehouse Road, Sunderland.

Mason, George F., Engineer, Fairhaven, Clive Road, Penarth.

McNeil, Thomas Young, Ship Draughtsman, 70, Meldon Terrace, Heaton, Newcastle-upon-Tyne.

Potts, Cuthbert Ivan, Engineer, 6, Rodsley Avenue, Gateshead-on-Tyne.

Stephen, John Murray, Engineer Draughtsman, Northumberland Engine Works, Wallsend-on-Tyne.

Williams, Thomas R., Ship Draughtsman, 178, Bede Burn Road, Jarrow-on-Tyne.

Wilson, John Paul, Shipbuilder, Messrs. Palmers Shipbuilding Co., Jarrow-on-Tyne.

Wilson, Thomas, Engineer Draughtsman, 6, Aiskell Street, Sunderland.

GRADUATES TO MEMBERS.

Forster, Alfred Lindsay, Engineer, Shaftesbury Place, Gateshead-on-Tyne.

Musgrave, Evers, Engineer, 147, St. Owen Street, Hereford.

Pendred, L. St. L., Engineer, 186, Portland Road, Newcastle-upon-Tyne.

Simpson, Kenneth, Ship Draughtsman, 41, Dalton Road, Barrow-in-Furness.

Wakeham, John F., Ship Draughtsman, 50, De Grey Street, Newcastle-upon-Tyne.

ASSOCIATES.

Arnott, James, Shipowner, etc., 25, Dean Street, Newcastle-upon-Tyne.

Turner, Edwin, Accountant, 32, Powell Road, Clapton, London, N.E.

GRADUATES.

Brown, Thomas Scott, Jun., Apprentice Engineer, 18, Nixon Street, Newcastle-upon-Tyne.

Burbidge, Alfred H., Apprentice Engineer, 15, North View, Heaton, Newcastle-upon-Tyne.

Carter, Thomas, Apprentice Engineer, 128, Sandyford Road, Newcastle-upon-Tyne.

Duckitt, Louis, Apprentice Engineer, Leazes Gate Villa, Spital Tongues, Newcastle-upon-Tyne.

Fraser, John H., Apprentice Engineer, New Winning Tavern, Wallsend-on-Tyne.

McCoull, Cecil, Apprentice Engineer, Ovington House, Ovingham, R.S.O., Northumberland.

McRae, Thomas, Ship Draughtsman, 40, Borough Road, Middlesbrough.

Thomas, William, Apprentice Engineer, 3, Chester Crescent, Newcastle-upon-Tyne.

Varty, B. S., Apprentice Ship Draughtsman, 16, Hawthorn Street, Newcastle-upon-Tyne.

Ward, Joseph P., Apprentice Engineer, c/o Messrs. John Spencer & Co., Newburn Steel Works, Newburn-on-Tyne.

Wildridge, Richard, Apprentice Engineer, 7, Alexandra Crescent, Newcastle-upon-Tyne.

The Council Report and Financial Statement for the eleventh session were submitted and adopted.

Mr. W. Cross read a paper "On the Surface Condensing Plant at the Newcastle and District Company's Electric Light Works, Forth Banks, Newcastle-on-Tyne." A discussion followed.

COUNCIL REPORT.

(Eleventh Session, 1894-95.)

In presenting its eleventh annual report the Council has pleasure in stating that the financial position of the Institution is still satisfactory, but regrets having again to report that it has been necessary to strike off a considerable number of members who, after numerous appeals, have still failed to pay up their arrears. This is most disappointing to the Council, as it not only means a large pecuniary loss, but also a loss of the *Transactions* issued to these members. With a view of reducing the amount of arrears at the close of the financial year, and to meet the desire of the Auditor, the termination of the Institution's year has been carried forward from the 31st day of May to the 31st day of July, and this has been embodied in the alteration made in Bye-law 6. The Council hopes that in the future all annual subscriptions which are due in advance on the first day of August in each year shall be paid before the end of the following month of April to admit of the funds of the Institution being duly disbursed, and the closing and placing of the Treasurer's books in the hands of the Auditor as early as possible after the close of the session. The Council has also had under consideration the desirability of having the Institution registered as an Incorporated Association under the Companies Acts 1862 and 1867, but the question has been deferred.

At the close of the last year the Institution held in trust the sum of £552 11s., being donations collected towards the stipend of the Professor of Naval Architecture and Marine Engineering in The Durham College of Science. During the year this sum has been augmented by further donations (see list, page 9) amounting to £60, leaving a total in the hands of the Council, including bank interest, of £617 7s. The Council being desirous of guaranteeing to The Durham College a further sum of £230 per annum for three years, Mr. Robert Thompson (Past-President), Mr. John Gravell (Vice-President), and the Secretary were deputed to wait upon the Principal of the College to ascertain whether it would be agreeable to them to receive the donation in yearly sums of £230, or that the total amount in the hands of the Council should be at once paid over. It being the desire of the College authorities that the total sum be at

once paid over. Mr. Robert Thompson (Past-President) placed in the hands of the Council a cheque for £72 12s. 6d. to be added to the above amount, thus enabling the Council to hand over to the College the full sum of £690.

The new iron measured mile posts have now been erected at Hartley, and the Council has received from the Ordnance Survey Department the official certificate testifying to the accuracy of the distances between the posts. The statement of the total cost of the posts, etc., will shortly be published, and steps will be taken to liquidate the debt. In the meantime Mr. Robert Thompson (Past-President) has kindly taken upon himself to meet all monetary requirements. A further sum of £19 12s. 6d. has been paid out of the funds of the Institution for repairs, etc., to the old posts, which sum will be included in the costs of the new. The Institution has undertaken to pay to Lord Hastings annually out of its funds the sum of £6 6s. for ground rent.

The eleventh session was opened with an address from the President (Ald. Thos. Richardson, B.A., M.P.) on the subject of electricity as a motive power. As the President desired to elicit the views of members upon this interesting matter the address was thrown open to criticism, which led to a most valuable discussion.

The following papers were also read and discussed during the session :—

1.—"A Brief Outline of the Theory of the Rolling of Ships." By Mr. Andrew Young.
2.—"An Account of some Experimental Studies of Ship Acceleration and Fluid Resistance." By Mr. F. Caws.
3.—"The Design and Efficiency of Plant for the Transmission of Power by Electricity." By Mr. W. C. Mountain.
4.—"The Application of the Electric Arc to Machinery and Boiler Repairs." By Mr. H. Foster.
5.—"Turret-deck Cargo Steamers." By Mr. S. O. Kendall.
6.—"The Metric System of Weights and Measures." By Mr. G. H. Baines.

No gold medals were awarded for the papers read during the tenth session.

The term of office of the four representatives of the Institution on the Surveyors' Sub-Committee of Lloyd's Register of British and Foreign Shipping having expired last December, the Council was called upon to appoint new representatives. The following four gentlemen were re-elected to fill the vacancies, and the best thanks of the Council was awarded to them for their past services, viz. :—Mr. William Boyd, Mr. F. C. Marshall, Mr. Robert Thompson, and Mr. Henry Withy.

A marked improvement has taken place in the Graduates' Section, and at both the meetings and the excursions there has been a better attendance. As an experiment one of the meetings was held in Sunderland, for which purpose Mr. F. Caws kindly placed his large room at the disposal of the Committee. The attendance at this meeting outnumbered that of any other meeting of the session.

During the session the following papers were read and discussed in this section :—

1.—"Steam Pipes and Fittings as found on Shipboard." By Mr. E. F. Baker.
2.—"Steam Steering Gears." By Mr. B. G. Nichol.
3.—"Railway Brakes." By Mr. J. Bowden.
4.—Discussion on Indicators and Indicator Diagrams. Opened by the Chairman, Mr. A. L. Forster.
5.—"Screw Propeller Shafting." By Mr. E. F. Moroney.

Visits were also paid to the following works :—

Messrs. George Clark, Limited, Sunderland ;
,, The North-Eastern Marine Engineering Co.'s Works, Wallsend-on-Tyne ;
,, R. & W. Hawthorn, Leslie, & Co., Locomotive Works, Newcastle-on-Tyne ;
,, Ernest Scott, Mountain, & Co.'s Works, Newcastle-on-Tyne ;
,, T. Richardson & Sons, Engineering Works, Hartlepool ; and
The Durham College of Science Engineering Laboratory.

The thanks of the Institution are due to the principals and officials of these various works for the kindness and courtesy shown on each occasion to the younger members of the Institution.

The awards for the best papers read before this section during the tenth session were given as follows :—

1st Award to Mr. Andrew Young for his paper on the "Launching of Ships." (This paper, in a more complete form, was read before the parent Institution during the eleventh session.)

The 2nd Award was divided between Mr. A. L. Forster for his paper on "High Speed Engines" and Mr. W. Oxton for his paper on "Pumping Arrangements for Ships."

At the closing meeting in May, Mr. A. L. Forster was re-elected Chairman of this section, and Mr. C. T. Adams, Hon. Secretary.

During the year the following additions have been made to the list of members :—38 Members, 10 Associates, 28 Graduates, and 7 Graduates have been raised to the rank of Members. The Council regrets having to record a rather heavy death-rate, and several members who have taken an active interest in the working of the Institution have been called away. Of Members, the following have been removed by death:—Messrs.

G. A. Calvert, R. E. Dickinson, T. Glover, F. Jorgensen, W. Kilvington (Vice-President), James Laing, Jun., Dr. Charles Mitchell, Messrs. E. Reynolds and R. H. Tweddell. Associates :—Messrs. W. Jenkins, A. Nicol, and J. Ward. Graduate :—Mr. J. L. Jamieson.

It has also lost from resignations and other causes 50 Members, 6 Associates, and 21 Graduates.

Owing to the lamentable death of Mr. W. Kilvington (Vice-President), who had been connected with the Institution from its formation, and was one who always took a warm and energetic interest in its workings and welfare, a vacancy has occurred in the list of Vice-Presidents, and the Council has elected Mr. James Patterson to fill his place.

Further additions have been made to the list of books in the library, and the following donations have also been received :—

Presented by.	Title of Book.
H. F. Swan, Esq. ...	"Naval Architecture." 3 vols. Scott Russell.
John Gravell, Esq. ...	"Steam Machinery and Steam Naval Architecture." 2 vols. By Tredgold and Woolhouses.
Ernest Scott, Esq. ...	Sundry volumes of Journal of the Society of Arts.

Owing to the increased attendance at the Graduates' meetings and the necessity for enlarging the library accommodation, the Council has pleasure in announcing that another large room has been obtained adjoining the rooms originally occupied, and a lease of five years has been entered into with the landlord for the whole of the rooms now occupied by the Institution; these rooms have been redecorated and fitted with the electric light. It is hoped that these alterations and additions will prove beneficial to all classes of members and enhance the value of the Institution.

Sundry alterations and additions have been made to the bye-laws, particulars of which will be found on page 346, Vol. XI., of the Institution's *Transactions*.

LIST OF SUBSCRIPTIONS

RECEIVED TOWARDS THE SALARY OF THE PROFESSOR OF ENGINEERING AND NAVAL ARCHITECTURE IN THE DURHAM COLLEGE OF SCIENCE, NEWCASTLE-ON-TYNE. FROM AUGUST, 1894, TO AUGUST, 1895.

	£	s.	d.
Messrs. T. Richardson & Sons, Hartlepool (third year) ...	20	0	0
„ Bartram, Haswell, & Co., Sunderland „ ...	10	0	0
„ Palmer's Shipbuilding Co., Jarrow „ ...	30	0	0
Robert Thompson, Esq. (Messrs. J. L. Thompson & Sons, Sunderland), donation...	72	12	6
	£132	12	6

NORTH-EAST COAST INSTITUTION OF
STATEMENT OF RECEIPTS AND PAYMENTS

Receipts.

		£ s. d.	£ s. d.
To Balance from last Account—			
At Bankers			334 11 5
„ Subscriptions received for Session 1894–95—			
245 Members at £2 2s.	£514 10 0		
440 Members „ £1 1s.	462 0 0		
110 Associates „ £1 1s.	115 10 0		
121 Graduates „ 10s. 6d.	63 10 6		
916		1,155 10 6	
„ Arrears for Session 1893–94—			
11 Members at £2 2s.	£23 2 0		
18 Members „ £1 1s.	18 18 0		
2 Associates „ £1 1s.	2 2 0		
6 Graduates „ 10s. 6d....	3 3 0		
		47 5 0	
			1,202 15 6
„ Transactions sold this Session		13 9 8	
„ Copies of Members' Papers supplied		81 16 4	
			95 6 0
„ Tyne Improvement Commissioners—			
One Year's Interest to 21st June, 1895, on £605, at 3¾ per cent.		21 18 6	
Viz.:—Medal Fund	£274 0 0		
Graduates' Award and Life Members' Fund	331 0 0		
	£605 0 0		
Less—Tax		0 14 5	
			21 4 1
One Year's Interest to 10th July, 1895, on £500, at 3¾ per cent.		18 15 0	
Less—Tax		0 12 6	
			18 2 6
„ Woods & Co.—			
Deposit withdrawn, being part of fund for Chair of Engineering and Naval Architecture		400 0 0	
Interest		4 16 6	
			404 16 6
Chair of Engineering and Naval Architecture Fund—			
Donations as per list			132 12 6
			£2,209 8 6

ENGINEERS AND SHIPBUILDERS.

FOR SESSION ENDING 31ST JULY, 1895.

Payments.

	£	s.	d.	£	s.	d.
By Transactions and Papers—						
Lithographing	179	12	9			
Printing and Binding	263	6	6			
				442	19	3
„ Stationery and Circulars	67	2	5			
„ Reporting	24	1	6			
„ Rents—						
Offices	65	4	0			
Lecture Rooms	10	13	0			
Telephone	8	0	0			
„ Rates, Gas, and Insurance	16	14	6			
„ Salaries—						
Secretary, Salary	275	0	0			
Do. Commission	60	2	9			
Assistant Librarian	35	0	0			
Office Boy	10	0	0			
„ Postage, Stamps, Post Cards, Parcels, etc.	90	18	4			
„ Secretary's Expenses and Allowances to Hall Keepers, etc.	21	7	3			
„ Office Expenses, Coals, Cleaning, etc.	14	10	0			
„ Rent for Measured Mile Posts	3	3	0			
„ Repairs, etc., to „	19	12	6			
„ Expenses of Graduates' Meetings and Hire of Lantern ...	3	15	0			
„ Auditor's Fee	3	3	0			
				728	7	3
„ Cost of New Furniture and Electric Light Fittings ...				48	4	2
„ Library Account—						
New Books	11	11	6			
Bookbinding	10	5	9			
				21	17	3
„ Chair of Engineering and Naval Architecture Fund—						
Balance of Fund paid over to College of Science ...				690	0	0
„ Graduates' Award Fund—						
Amounts Awarded for Papers				7	11	9
„ Balance—						
At Bankers...				270	8	10
				£2,209	8	6

THE BALANCE SHEET.—FOR THE SESSION ENDING 31ST JULY, 1895.

Liabilities.

		£ s. d.	£ s. d.
Gold Medals' Fund—			
Amount at 31st May, 1894		281 13 7	
Interest on Investment		9 12 1	
			291 5 8
Graduates' Award Fund—			
Amount at 31st May, 1894 ...	£223 6 8		
Interest on Investment ...	7 11 3		
		230 17 11	
Less—Awards for Papers		7 11 9	
			223 6 2
Payments by Life Members and Associates—			
Amount at 31st May, 1894			126 0 0
General Capital			1,323 11 6
			£1,964 3 4

Assets.

		£ s. d.	£ s. d.
Subscriptions in Arrear—			
Session 1892-93		2 2 0	
„ 1893-94		17 6 6	
„ 1894-95		62 9 6	
			81 18 0
Stock of Transactions, valued at			162 19 0
Office and Library Furniture, Safe, etc., as at 31st May, 1894	£109 11 5		
Less Depreciation and Gas Fittings	19 19 0		
		89 12 5	
Additions this Session		48 4 2	
			137 16 7
Books in Library—			
As at 31st May, 1894 ...	£171 6 3		
Less Depreciation	17 2 7		
		154 3 8	
Additions this Session—			
Purchases	21 17 3		
Books received in exchange ...	30 0 0		
		51 17 3	
			206 0 11
Tyne Improvement Commissioners—Investment in respect of the following Accounts, viz.:—			
Gold Medals' Fund		274 0 0	
Graduates' Award Fund		215 15 0	
Payments by Life Members and Associates		115 5 0	
General Capital		500 0 0	
			1,105 0 0
Cash—At Bankers			270 8 10
			£1,964 3 4

Newcastle-upon-Tyne, 1st October, 1895.

Audited and certified,
R. W. SISSON, F.C.A.

Mr. WILLIAM BOYD (Past-President) said he had been asked to move the adoption of the Council's report on this occasion, and he thought that, considering the number of years that had passed over since the Institution was formed, the record of its present position might be taken as satisfactory. He would like to call the attention of the members to the last clause in the first paragraph, that relating to the arrears of subscriptions, and he spoke somewhat feelingly, being chairman of the Finance Committee. One of the great difficulties they had to contend with was the difficulty of inducing members to pay up their subscriptions. It seemed to him almost an incredible thing that a man should take upon himself the responsibilities of membership in such an Institution as this in such a light hearted way as to enjoy the Institution without first seeing his way to the continued payment of his subscription; because, though he did not know the exact proportions, the arrears were mainly from those who just joined for a year or two, and it seemed to him indicative of a great want of self-respect that gentlemen should be willing to join an Institution, take the *Transactions* for a year or two, and then quietly allow their names to be struck off the list. The Council had had the question of the incorporation of the Institution before it; unfortunately it would cost a considerable sum, he did not know exactly what, but something considerable. He was not at all sure it might not be an economy, for if they were incorporated it would enable them to sue those gentlemen who joined the Institution and afterwards failed to pay their subscriptions. Those members who had lately been in the new rooms could not, he thought, fail to be struck with the great improvement in their appearance and the additional room and comfort provided. There was now growing up an excellent library and large reading room, supplied with an overwhelming amount of technical papers, enough to turn any man's head; and he hoped the facilities afforded there would be appreciated by the members, and possibly induce an increase in the number. He could only hope that that increase would be of a payable description. He did not know that he need say any more. He begged to move the adoption of the report.

Mr. GEO. N. ARNISON, Jun., had much pleasure in seconding the adoption of the report. As regarded the subscriptions might he make a suggestion. In many societies, no one became a member until they had paid their first year's subscription. There might, he thought, be a rule to that effect.

The PAST-PRESIDENT—It is so now.

The SECRETARY (Mr. Duckitt)—No one is considered a member of the Institution until he has paid his first year's subscription; but after that he stands to receive the *Transactions* for two years and yet may not pay for the second year.

Mr. ARNISON (continuing) said there was one thing in the report to be specially noted, and when he came to mention it he felt that he would rather Mr. Thompson had not been in the chair. He would rather that he was addressing the President when he alluded to the very generous action Mr. Thompson had taken in making up the £690, the three years' guarantee for the professorship. When he first saw in the report that Mr. Thompson had given a cheque for the balance, he came to the conclusion that Mr. Thompson had been the father of the scheme, or, at all events, was President when the proposal to have a naval architect and marine engineering professorship was mooted, and was therefore determined to carry it through, but he found on enquiry that that was not the case. Mr. Thompson's action, therefore, commended itself all the more to them for the very handsome way in which he had acted. Then they came to the erection of the new mile posts, and there they found Mr. Thompson again acting most generously as financier to the Institution, taking upon himself, for the time being at any rate, to "meet all monetary requirements." It was to be hoped, however, that the various large engineering and shipbuilding firms in the district would come forward and do their share in defraying the expense. He seconded the adoption of the report.

Mr. FRANK GRAHAM desired to make one remark. He saw that the balance at the end of the financial year was some £60 less than a year ago. That was a matter which he did not think they could congratulate themselves upon, and his only excuse for delaying the adoption of the report was to say that in his "comings and goings" he found a surprising number of gentlemen connected with the engineering and shipbuilding trades who were not members of that Institution, and who would probably become members if the *modus operandi* was easy and just at hand. He had himself recently taken about with him one or two nomination forms, and in speaking of the Institution he generally found that it was the case of a man not taking the trouble to become a member. If he said, "Just sign your name and I'll do all the rest," he got a new member. Now, he would just like to suggest to the members of the Institution that if they would carry a few of the nomination forms in their pockets—he was sure Mr. Duckitt would be very pleased to supply

them—they might easily increase the membership, and perhaps next year, instead of a reduction of the balance at the bankers they might have an increase.

The SECRETARY (Mr. Duckitt) begged leave of the Chairman to explain that, so far as the amount at the bankers was concerned, it was more this year than last. Of the £334 11s. 5d. then appearing in the balance of accounts, £152 11s. belonged to The Durham College of Science. Now, the balance of £270 8s. 10d. was entirely their own money.

Mr. D. ANDREW said in looking over this report, and seeing the large amount of money represented by arrears of subscription, an effective means of recovering a large portion might result from publication. He had no doubt many of the gentlemen who had delayed or forgotten altogether to pay their subscriptions did so through want of forethought, bad memory, or something of that sort; and he had no doubt their worthy Secretary (Mr. Duckitt) had done all in his power to bring it before them. He thought, however, one thing more might be done, namely, to post up a list of the names in the Institution rooms. If that were done in view of everyone, that might have some good results, and shake up their memory.

The PAST-PRESIDENT (Mr. R. Thompson) in reply to Mr. Graham, further explained that they had paid £48 to defray the cost of new furniture in the extension of premises, and the electric light installation. They had got better premises and more stock, the value of which might otherwise have appeared in the cash balance.

The reports were then unanimously accepted.

THE GOLD MEDALS.

The PAST-PRESIDENT said that it appeared from the circular there was to have been a presentation of two gold medals for papers read during the eleventh session: the engineering medal to Mr. Henry Foster for his paper on "The Application of the Electric Arc to Machinery and Boiler Repairs;" the shipbuilding medal to Mr. Stonard O. Kendall for his paper on "Turret-deck Cargo Steamers." Unfortunately neither of these gentlemen could be present that night.

The SECRETARY (Mr. Duckitt) read a communication from Mr. Stonard O. Kendall, Glasgow, and Mr. Henry Foster, Old Trafford, both expressing regret for absence on account of pressing business engagements.

The PAST-PRESIDENT said he would ask Mr. Duckitt, on behalf of the Institution, to forward the medals to those gentlemen and wish them every success in their future career.

OPENING REMARKS BY THE PAST-PRESIDENT.

The PAST-PRESIDENT (Mr. Robert Thompson) said they had had the letter from Mr. Richardson read, and he (Mr. Thompson) was sorry the President could not be present at this the first meeting of the twelfth session. He did not intend to make any lengthy remarks, as he thought any remarks made from the President's chair to an Institution of that kind should be worth listening to, and have had some preparation, so that what was laid before them would be worthy of consideration and of the Institution and President. He did not feel equal to this position on so short a notice, and consequently he would not occupy their attention more than a few minutes and in a desultory way. He might say in regard to what had been said with reference to the College, that the report did not quite explain the position. The Chair of Engineering and Shipbuilding was now permanently established. On the Institution undertaking to endow it for a further three years the College authorities undertook on their part to carry the chair on permanently, so that from the Institution's efforts in the first place in getting an appointment to the chair, in raising subscriptions to support it for three years, and now for another three years, there had resulted the permanent establishment of this professorship in the Durham College of Science. He was very glad to report that the College authorities were very much pleased with this additional department of the College. The members attending, and the instruction given there, was everyway satisfactory to all concerned, and he was quite sure that they would feel great pleasure in having been instrumental in setting up a permanent means for scientific instruction in their kindred professions in this district. With regard to the mile posts he might say all the accounts had been paid, and as soon as they had a Council meeting the matter would be settled, and so clear off the only arrears of work occurring while he was President. There was only one other thing he would like to mention. He could never forget Mr. Boyd's opening address, and here they had the very subject he spoke of taken up, the management and laying out of works. For that reason he was very sorry the President was not there that night, for his opening address dealt very largely with this subject, and it was purely the result of that address that they had now got a paper from Mr. Cross touching on the same subject. He hoped some other members of the Institution

would take the hint and let them have some papers during this session dealing with the subject, for Mr. Duckitt told him that at present they were rather short of shipbuilding papers. He was perfectly certain if they could have a paper upon the management of works or arrangement of plans and appliances in the shipyard that they could have a very interesting paper, which would lead to discussion, and, he was sure, would be of great benefit to all of them. From his experience of shipyards it seemed a case of everlastingly altering. Times moved so rapidly now, money-making was getting, perhaps, more difficult, and, in order to attain the utmost efficiency, his experience was that for two or three years they appeared to have been undoing practically what they had done before—spending money without knowing how far it was going to be recouped. Competition, however, was so keen they could only keep in the market by advancing with the times. This renewal work, however, was a subject well worth consideration. It appeared to him that there were firms who could go on without alteration, while others went on spending money; and it had come very much to a point as to how far one was justified in being at the head of the times or even up to the times. Then, as to the size of ships, he was sure they might have an interesting paper on the question as to whether it was more profitable to have ships of 10,000, 12,000, or 14,000 tons, or to divide these figures by 2 and have two ships. He thought that if some of their shipbuilding friends would write them a paper upon the rise of shipbuilding and its progress during the last ten or fifteen years they could have a very interesting discussion. Not the least valuable part of their *Transactions* was the discussions that followed the papers, and dealing with such subjects as he had alluded to, which increased the value of the Institution. They had had prognostications of what trade was going to be, but he was not going to attempt any; he thought it better to wait until events developed themselves. It seemed to him latterly that the development of trade was very often interfered with by speculators outside of the legitimate traders. They affected material markets and injured *bona fide* business, as far as shipbuilding and engineering were concerned. Whether it was an advantage to the country to have too much money or otherwise was a point open to discussion; but it did seem to him that there was too much floating capital in the country, of which advantage was taken by speculators and trade interfered with. The rapid transit of material from one point of the world to another, the advices possible by telegraph, brought things to such a point that whenever trade began to improve there were certain

speculators who jumped into business, and the prospects of legitimate trade for the time was barred. Whether the needs of the world were so growing that they meant to have a good time he could not say; they could only wait and hope for the best. Certainly the volume of trade in the country was greater, and if they could get over the winter perhaps things would be better. For all interested he hoped it might be so. He had one pleasant duty to perform, that was, to propose a vote of thanks to the President for the conversazione they had had the previous week. These functions were begun by Mr. Wigham Richardson, and they seemed now a part of the proceedings of the Institution. He was quite sure that those of them who attended last Friday fully enjoyed the evening. He thought it was a pleasant thing for them to get together without discussion; to have their lady friends, who for one night in the year could have some amount of pleasure as compensation for the number of nights they left them alone. He moved that the best thanks of the Institution be given to the President for the conversazione in Newcastle.

The motion was carried by acclamation.

ON THE SURFACE CONDENSING PLANT AT THE NEWCASTLE AND DISTRICT COMPANY'S ELECTRIC LIGHT WORKS, FORTH BANKS, NEWCASTLE-ON-TYNE.

By WILLIAM CROSS.

[Read before the Institution in Newcastle-upon-Tyne, on October 25th, 1895.]

In 1892 the Newcastle and District Electric Lighting Company, Limited, decided to put down an independent surface condensing plant for the purpose of economising the consumption of steam, and as this plant differs to some extent with ordinary practice a short description may prove of interest to the members of this Institution.

The generating plant for which the above was designed consisted of two Parson-turbo motors, each of which, when running at full load and at 4,500 revolutions per minute, gave about 250 effective horse-power. These motors were supplied with steam at 140 lbs. pressure. The motors are designed to expand the steam about 150 times, thus giving a theoretical terminal pressure of 1 lb. It was therefore obvious that an air pump of ordinary construction could not maintain a vacuum nearly perfect enough to be of any service.

The situation was a somewhat difficult one, the point at which the condensing plant had to be fixed being 90 yards and the floor level 36 feet above low water springs in the river Tyne, which was the only available source from whence the water necessary for condensation could be obtained. It was, moreover, a point of special importance that the plant should be capable of running continuously for very long periods without stoppages for repairs or adjustments. The surface condenser was required to have 1,500 square feet of cooling surface, and the pumps, etc., had to be made of suitable size for dealing with plant of such capacity. Owing to the height the condensing water would have to be lifted and the great length of the suction pipe, it was considered desirable to keep the condenser and pumps as low down as possible, and, in view of the continuous running required, to keep the engine on the floor level, so as to be well in view and easily accessible.

The arrangement finally determined on is shown in Fig. 1 (Plate I.), where the tandem compound pumping engine is shown carried on beams over the top of the shaft, whilst the condenser and pump are placed at the bottom, the pumps being connected to the rocking beam of the engine with wooden spear rods. The shaft is 10 feet in diameter, and from the bottom of it a drift 260 feet long, and of a cross section of 4 feet 6 inches by 4 feet 6 inches is driven to the river, which it meets at about low water level.

Down the drift run two cast iron pipes, each 12 inches diameter, one being the suction and one the return. These pipes are continued well into the river, the suction pipe being fitted at the end with a short length of flexible hose with wind-bore and float so arranged as always to keep the extreme end well clear of the mud.

As the surface condenser is of perfectly ordinary construction it has not been thought necessary to give a detail drawing of it. A portion of it, however, may be seen in Fig. 1 (Plate I.); it is 4 feet 6 inches in diameter and 9 feet 8½ inches long between tube plates; and contains 790 brass tubes ¾ inch in diameter, giving a cooling surface of 1,512 square feet. The exhaust steam is brought to the condenser by light galvanized wrought iron pipes, about 2 feet in diameter.

The engine is a tandem compound, on Kingdon's system, designed to run constantly at 60 revolutions per minute, having two cylinders 6¼ inches and 11½ inches by 9 inches stroke, a detail of the cylinders and slide valve is given in Fig. 2 (Plate II.). It will be seen that there is no intermediate gland, a corrugated piston rod working through a long bush being used instead. There is only one slide valve, which is cast hollow, the exhaust from the high pressure passing through the back of the valve and into the low pressure, there is therefore only the slide spindle gland exposed to high pressure steam, a point of importance in view of the long runs required. It will be seen that on the upstroke the corrugations of the rod constantly entering the bush tend to check any leakage of steam, and this they effect most completely, whilst on the down stroke the bottom of the high pressure and the top of the low pressure are in connection through the slide valve, and any leakage past the rod is a matter of unimportance. The rocking levers are double-ended, and are connected to the cross-head by links in the usual manner; the outer end of the levers drive the circulating pump of 1 foot 6 inches stroke. Nearer to the fulcrum is attached the spear rod of the cold water pump, which is 9¼ inches stroke, and at the inner end of the lever is the air pump spear rod, of 1 foot 6 inches stroke. There are two

fly-wheels . . . one on each end of the crank-shaft, so that all strains are symmetrically distributed. The engine is controlled by a Tangye governor, but this is only intended to come into play in case of a spear rod breaking or a pump missing its water. The cold water pump is an ordinary ram pump, 4 inches by 9¼ inches stroke, taking the water delivered by the air pump, and delivers against a head of about 50 feet into a feed-water tank in the boiler room. It is driven by a light spear rod made of wrought iron tube.

The circulating pump is shown on Figs. 3 and 4 (Plate III.). It is double-acting on the constant pressure system, which has the advantage of diminishing the number of valves required and doing away with any valves in the bucket. This pump is 1 foot 6 inches stroke, the bucket being 1 foot 2 inches, and the ram 10 inches in diameter; it is estimated to deliver 550 gallons of water per minute at 60 double strokes. The valves are of the ordinary india-rubber disc pattern, and are arranged so as to be very easy of access. It will be seen that the pump draws only on the upstroke; on the down stroke it delivers all the water to the top or ram side, but that as the ram is one-half the area of the bucket, one-half of the water is displaced and delivered into the condenser; on the succeeding upstroke the second half is delivered. The delivery is therefore practically constant, whilst the suction is intermittent. The velocity of water through the valves is 5 feet 6 inches and in the suction pipe 3 feet 6 inches per second. To prevent shocks in the suction pipe, due to the intermittent flow, an air vessel of 11·25 cubic feet capacity was fitted, as shown in Fig. 1 (Plate I.). The water after being forced through the tubes of the condenser passes back to the river through the second or exhaust 12 inches pipe already mentioned, the effect of this being that the head is balanced by the suction of the delivery, and the work on the pumps very considerably reduced.

As already mentioned, so high a vacuum was required that an air pump of ordinary construction could not be expected to deal with it, and one of special construction had to be constructed.

In an ordinary air pump the clearances are so large as compared with the volume swept by the piston that at very high vacuums the vapour is never compressed sufficiently to attain the atmospheric pressure plus that required to lift the valves, consequently on the next outstroke the vapour simply expands again and fills the barrel without any suction having taken place. It was therefore decided to break up the compression of the vapour into stages, so that the compression in any one cylinder would be but small, and the difficulty mentioned would not arise. Fig. 5

(Plate IV.) shows a section of an experimental air pump made to see what vacuum could be obtained, and in which the process is broken up into four stages. In this model all the valves are worked mechanically to relieve the vapour of the work of lifting them. The design is very like an ordinary pair of tandem cylinders. The vapour enters under the bottom foot-valve A. This valve is worked by the friction of the tail rod working in a prolongation of the valve, which forms practically a bush, and it is kept from rising too far by a cage, which fits over it and limits its lift. The same method of working also applies to the diaphragm valve C and the top exit valve E. The two pistons, B and D, are loose on the rod, which has a slight play allowed between two collars, the lower collar forming the valve in each case.

As drawn, the pistons are shown on the down stroke. A, C, and E are therefore closed, whilst B and D are open, the vapour has thus a free passage from the lower to the upper sides of the two pistons. On the commencement of the upstroke the valves B and D are at once closed and A, C, and E are opened. The vapour then has free communication from the condenser to the under side of the lower piston; from the upper side of this piston to the under side the top piston and the top side of the latter is open to the atmospheric pressure.

As there is, on the down stroke, free communication between the top and bottom sides of the pistons practically no compression can take place on the under side, and owing to the difference in areas of the two cylinders the vapour is only compressed from X to $\frac{AT}{2}$ in the upper part of the large cylinder and from $\frac{AT}{2}$ to AT in the upper part of the small cylinder.

The experimental pump is here exhibited, and it will be seen that though no special precautions have been taken in the way of piston packing, fitting, etc., to prevent leakage, yet when driven at about 100 revolutions a minute, without any water, an almost perfect vacuum was attained, certainly within ·1 inch of mercury. This was a better vacuum than was required, and the pump as finally made was somewhat simplified, there being only one cylinder, and a differential piston, somewhat the same as used for the circulating pump. With this pump a vacuum within ½ inch of the barometer is easily maintained for weeks, even months, at a time.

Having now briefly described the plant, it only remains to give the general results.

A few difficulties were experienced at the first, but these were easily overcome, and the plant has been working continuously ever since. It

generally runs for about six months on end without stopping, and practically without attention of any kind. Though only a part of the plant works into the condenser . . . the results so far have been very satisfactory. The cost of coal (at the same price per ton) per Board of Trade unit has dropped nearly 50 per cent., and the cost of water about 70 per cent., as taken over six similar and consecutive months in each case, a saving sufficient to pay the whole cost of installation in about three years, and this result would have been still more favourable had it not been for the unavoidable expense of the shaft and drift.

Surely these figures are worthy of the attention of the owners of the numberless high pressure non-condensing engines in this district, and who are in most cases much more favourably placed as regards site and facilities for obtaining condensing water than in the present case.

In conclusion, the thanks of the author are due to the Newcastle and District Electric Lighting Company, to the Hon. C. A. Parsons, and Mr. William Hunter, the engineer to the company, for their kindness in affording him the necessary information to enable him to complete this paper.

The PAST-PRESIDENT intimated that the discussion on the paper would be adjourned to the meeting to be held on December 17th, in Sunderland, the Hartlepool meeting being kept free for a paper to be read and discussed at it.

Mr. WM. BOYD said as he might not have an opportunity of going to Sunderland when this paper was to be further discussed he would like to express their thanks to Mr. Cross for having brought forward a subject which, he thought, was one which deserved, perhaps, more attention than it received at the hands of the members of this Institution. He endorsed the regret Mr. Thompson had expressed that the President was not present, for there was no doubt his address a year ago alluded to this great question of the economy in the conduct of works. That was one of the subjects he (Mr. Boyd) had always felt could be usefully attended to by members, and on which some very interesting papers and discussions might be produced, for they often found that papers most interesting and most useful in eliciting the opinions of the members were not those that required most elaboration in their preparation, but introduced

subjects that were in the common experience of everybody, and which appealed to their interest in their daily work. The subject that Mr. Cross had introduced to them that evening was one which for some time past—for some years past—he had been endeavouring to see carried out at the works with which he was connected, but like many other things it got overlooked in the press of business and the exigencies of other things. It rather curiously happened that, without knowing this paper was about to be read, he was engaged going into some calculations and estimates as to the cost, and the results that would be obtained in fitting up a condensing plant to receive the exhaust from some half a dozen high pressure engines at present engaged in driving their machinery. He thought the great difficulty that had to be met, and towards which this paper certainly gave very great relief, was the cost of the circulating water—the cost of passing the circulating water through the condenser in any ordinarily established shipyard or engineering works. Of course, a shipyard would perhaps be more favourably situated than an ordinary engine works, for, at any rate, the shipyard must be close to the water; but the difficulty lay not in carrying the exhaust from the engines to the condenser—not perhaps so much in the air pump—but the difficulty lay in getting a circulation of water through a condenser on anything like economical terms. Of course, in many of their establishments the boilers were supplied with water from Whittle Dene or other supplies of that character, and of course it would be quite out of the question to use Whittle Dene water as the circulating water. It seemed to him that the question of the cost of that part of the installation was really the keynote of the situation, and it was extremely encouraging to him, at any rate, to find that Mr. Cross stated in his paper that, notwithstanding he had included in the cost of circulating the water the long drift to the river and a well so many feet deep, and, moreover, a costly mode of applying the circulating and air pumps, for these fittings must have cost very much more placed at the bottom of the well than they would have done if placed at the surface, Mr. Cross showed that a great saving could be effected in the consumption of water—he took it to be on Whittle Dene water—(Mr. Cross—"Yes")—and on the coal burned, even with such a costly installation as this, for it was obvious to anyone that the circumstances were against them all the time—then he (Mr. Boyd) said it seemed to him to be a very great encouragement to all of them to look into this question, and times like these, when there was no profit to be made at all, were the most suitable for examining into everything connected with the

economy of works. It was a curious thing how one thing led to another; and somehow the moment of time seemed to become ripe almost without knowing it for a certain question. He had only that day had his attention drawn to the condensing and feed-heating plant—he thought the name was Wright's condenser, a London firm in Victoria Street or Great George Street—in which the saving they undertook to effect anywhere where circulating water could be obtained with anything like reasonable facility curiously enough tallied very closely with the figures given by Mr. Cross. The statement he had seen that day in connection with some works—not his own, but some engineering works in the district—indicated a saving of 58 per cent. on the coal cost. Well, that worked out approximately to something like what Mr. Cross had indicated in his paper. Of course, they were all very familiar with the success that attended feed heaters, water cleansers, and grease extractors, and the large family of patents that flourished so successfully on board ship; and it appeared to him that some of those valuable patents might be applied very successfully for land work in their factories. And speaking for himself, as intimately connected with the management of a large factory, he was very greatly indebted to Mr. Cross for having called the attention of this Institution to such an important subject. Either that night or some other night some members more competent to deal with details would discuss the question, particularly as to this quadruple air pump of Mr. Cross's design; but that was not a subject he would venture to occupy their time with now. He desired to express his sense of the importance of the subject to the members of this Institution.

The PAST-PRESIDENT, finding no one disposed to make any remarks, said they would adjourn the discussion to the Sunderland meeting. He thought they might take it as a compliment to Mr. Cross, that the success of the arrangement described in his paper put it above criticism. It spoke well for Mr. Cross's firm that they had achieved such a success. He was always glad to see anyone moving ahead in the way of economy, especially with large works. Engines are sometimes placed in works which do not prove economical. They might get 20 per cent. economy in a marine engine, and in addition so much from a feed heater, so much from a grease extractor, and other contrivances, which would show a considerable saving. Here they had a saving which in three years would pay for the whole of the plant. In his works they always went for a machine or alteration which would leave 15 per cent. margin, and the effect of this on the question of cost was very favourable. There was no

doubt immense waste, especially in shipyards. He had often said that he would be content to take the waste of a shipyard for his income. These were times requiring economy all round, and such economy as was shown in papers similar to the one just read by Mr. Cross, deserved every attention from this Institution.

The meeting concluded, further discussion on Mr. Cross's paper being postponed to the December meeting in Sunderland.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

TWELFTH SESSION, 1895-96.

PROCEEDINGS.

SECOND GENERAL MEETING OF THE SESSION, HELD IN THE ATHENÆUM, WEST HARTLEPOOL, ON SATURDAY EVENING, NOVEMBER 16TH, 1895.

J. R. FOTHERGILL, ESQ., VICE-PRESIDENT, IN THE CHAIR.

The VICE-PRESIDENT said he had two telegrams to read. 1st, from the President :—" Regret much cannot attend meeting. Kindly take my place." 2nd, from Mr. Duckitt (the Secretary) :—" Sorry unable to be with you to-night." He (the Chairman) was sure they would all regret the absence of the President who, he might say, had so many calls upon his time that he found it impossible to be with them that night. He also felt sure they would all deeply regret and be sorry to hear their genial and obliging Secretary had most unfortunately happened an accident by straining some of the sinews of his leg, and that he was at the present moment confined to his bed, but he hoped soon to see him about again. He called upon Mr. Wallace (the Assistant Librarian) to read the minutes of the last General meeting.

The minutes of the last General Meeting, held in Newcastle-upon-Tyne, on October 25th, 1895, were read, approved by the meeting, and signed by the Vice-President.

The ballot for new members having been taken, the Vice-President appointed Messrs. H. Macoll and G. W. Sivewright to examine the voting papers, and the following gentlemen were declared elected:—

MEMBERS.

Bewlay, Charles J., Ship Draughtsman, 5, Warrington Road, Newcastle-on-Tyne.
Crofton, Charles, Engineer, 17, Albany Terrace, Whitley, near Newcastle-on-Tyne.
Wilson, Henry J. H., Engineer, 117, Bede Burn Road, Jarrow-on-Tyne.

GRADUATE TO MEMBER.

Hamilton, Robert C., Engineer, Messrs. Stabilimento Armstrong, Pozzuoli, Naples, Italy.

ASSOCIATES.

Holliday, Henry, Secretary and Commercial Manager, Messrs. Consett Iron Co., Beechgrove, Blackhill, County Durham.
Hudson, Robert, Secretary, Messrs. C. S. Swan & Hunter, 24, Hotspur Street, Tynemouth.
Todd, John Stanley, Underwriter, Percy Park, Tynemouth.
Whitfield, John, Shipowner, Blyth.

GRADUATES.

Bulmer, Albert Edward, Apprentice Engineer, 2, Graingerville North, Newcastle-on-Tyne.
Hepburn, James M., Apprentice Engineer, 17, Grosvenor Place, Jesmond, Newcastle-on-Tyne.
Lace, Basil Theodore, Apprentice Engineer, 26, North View, Heaton, Newcastle-on-Tyne.
McIlwraith, Charles H. C., Apprentice Engineer, 3, Kayll Road, Sunderland.
Pashby, Arthur, Apprentice Engineer, 10, Campbell Street, Newcastle-on-Tyne.
Posgate, James Stephen, Apprentice Engineer, 18, North View, Heaton, Newcastle-on-Tyne.
Shand, William Lamont, Apprentice Engineer, 64, Osborne Road, Newcastle-on-Tyne.
Townend, Sidney, Apprentice Engineer, 10, Cambridge Street, Newcastle-on-Tyne.

Mr. J. Denholm Young, M.I.N.A., read a paper "On the Application of the Law of Similarity to Marine Propellers."

A discussion followed.

Mr. G. H. Baines reported to the Institution what had been done in reference to the Metric System of Weights and Measures.

ON THE APPLICATION OF THE LAW OF SIMILARITY TO MARINE PROPELLERS.

By J. DENHOLM YOUNG, M.I.N.A.

[Read before the Institution in West Hartlepool, on November 16th, 1895.]

It was pointed out by Rèech that the laws of similarity applied to the complete behaviour, with certain well-known restrictions, of a model of a paddle or screw steamer in which all the observed speeds were proportional in the model and in the steamer to the square root of the linear dimensions.

The influences affecting the hull and engines have been noticed by the writer in a previous paper,* so that at present attention may be directed to the propeller alone.

It will be understood that by similar screws are meant screws of the same pitch-ratio and configuration, and by similar paddles those that are the same in form and number of floats, and in the ratio of breadth and depth of float to diameter of paddle.

When linear velocities are directly proportional to $\sqrt{\text{dia.}}$, revolutions of similar screws or paddles are inversely proportional to $\sqrt{\text{dia.}}$, as can be seen by the elementary reasoning in the Appendix. A parallel illustration of this law is that the number of oscillations of pendulums are inversely proportional to $\sqrt{\text{length}}$.

When the real slip-ratio is identical, in the case of model and ship, the similarity of motion of the propeller through the water is complete.

It may, therefore, be taken as a starting point that, with similar propellers, when the revolutions vary inversely as the square root of the diameter, and the real slip per cent. is identical in the model and in the steamer, the thrusts vary as the cubes of the diameters, and the indicated horse-power as diameter$^{7/2}$.

* *Trans.*, Vol. IX., page 71.

The above generalisation does not necessarily conflict with the theories of propeller action enunciated by well-known writers at different times. Broadly speaking, whatever theory or convention we adopt in analysing the action of propellers, the law of similarity is implicitly included in the analysis, with propellers just as with ships.

It is at once seen that a series of experimental constants, such as those obtained by Mr. R. E. Froude, can be readily transformed and operated with under the law of comparison, as also can the equations suggested by Mr. Thom, and adopted by Mr. Barnaby and others. (See Appendix I.)

In the above systems there is the underlying assumption that with a given propeller at constant efficiency, the indicated horse-power varies as the cube of the speed.

The law of comparison is satisfied if this is the case. It is also satisfied with a wider assumption, namely, that at corresponding speeds the indicated horse-power can be expressed by the following formula for similar propellers :—

$$\text{I.H.P.} = \text{constant} \times (\text{dia.})^x \times (\text{speed})^y,$$

in which at all times

$$y + 2x = 7.$$

As this can give an indefinite number of values of x and y, it will be more convenient to dispense with constants and deal with actual speed and power results, treated under the law of comparison.

Some of the factors which fulfil or modify the action of this law may now be considered in detail.

1.—Indicated Horse-power and Thrust.

For the purpose of making the results of this paper more generally applicable to rapid calculation, gross indicated horse-power, subject to certain correction, will be implied. In making a transition from one type of machinery to another, or from one form of vessel to another, the various efficiencies will have to be taken into account, as different types will be found to differ considerably. In general, it appears that the amount of initial friction in machinery is decreasing with modern progress.*

Mr. Froude's figures of average results are well known, and for the sake of reference are given here.

* See Taylor, *Resis. of Ships*, page 134.

	I.H.P.
Initial friction	= ·130
Friction of load	= ·130
Air pump, etc.	= ·07
Screw	= ·129
Thrust deduction	= ·154
Effective horse-power	= ·387

In taking data from graduated trials at points below full speed, for adaptation to full speed of another steamer, a small allowance may be necessary on account of the disproportionate friction of the two engines at corresponding powers. This allowance may be put in the form of a factor transforming the indicated horse-power at reduced speeds, to what it would be *if the cylinder volume, instead of the pressure*, were reduced, and will approach the following average values, where *i.h.p.* = power of engines at reduced speed, I.H.P. = power at full speed :—

Ratio $\frac{i.h.p.}{I.H.P.}$.	·1	·2	·3	·4	·5	·6	·7	·8	·9
Multiplier to be applied to corresponding I.H.P. ...	·8	·835	·865	·895	·922	·947	·97	·985	·995

The purpose of these factors is, of course, different from the μ in Mr. Hök's paper of 1893, where the engines are not tied to a particular propeller.

2.—Slip.

The speed of the wake must be added to the apparent slip for our present purposes. Apparent negative slip is now so well understood that it is not necessary here to do more than refer to it, as being a common occurrence with long and full vessels.

3.—Wake.

This factor is not yet fully investigated as to its absolute amount. A valuable paper on the subject will be found in *Trans. I.N.A.*, 1893, contributed by the late Mr. Calvert.

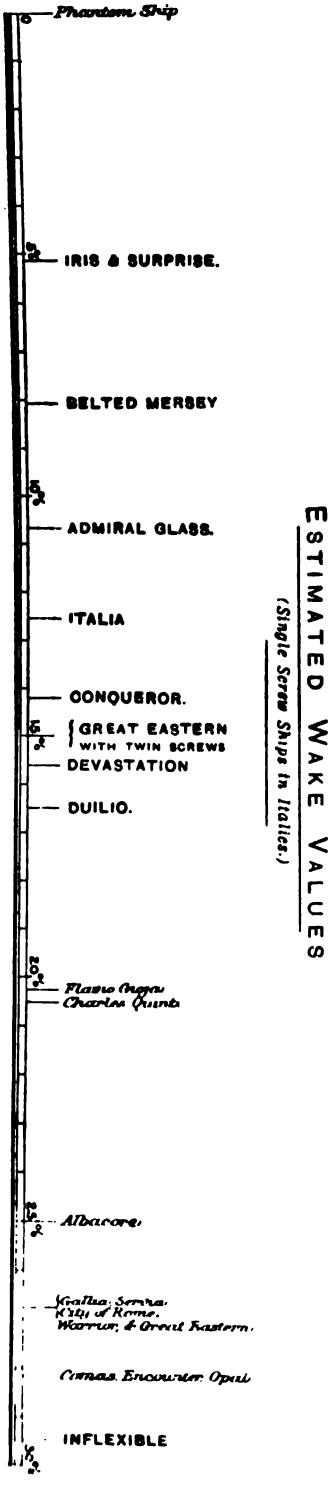
It appears that the amount of wake motion depends chiefly upon—

1. The form of the vessel.
2. The nature and amount of wetted surface.

The effect of *speed* upon wake value is not yet known, and will probably be most felt at the period known as "limiting speed."

A scale showing the estimated values of the wake of several classes of ships is given on page 34, with the kind permission of Mr. R. E. Froude, taken from his paper on propellers in *Trans. I.N.A.*, 1892.*

* From this and other data the writer has constructed the diagram on Plate VII. giving average wake values.



REPRODUCED WITH PERMISSION OF MR. R. E. FROUDE.

It will be seen from reference to it that as a rule the wake value for single screws is very much larger than in the case of twin screws. A vessel in which a large portion of the propeller projects below the keel, as in some torpedo boats, may be expected to have about the same wake value as a twin screw of the same size and fulness. Likewise the centre screw of a triple screw vessel, though working in a heavier wake than the wing screws, will, if placed as low as it can be, be found to work in water, having comparatively less forward motion than if the propeller had reached nearer the surface, where the wake motion is greater.

If differences of wake are not justly taken into account in comparisons of screw performance, it will appear as if the law of similarity were not fulfilled. In fact the performance of the propeller, when properly interpreted, is a good test of the amount of wake in actual cases.

Mr. Barnaby has pointed out that the correction for wake causes us to adopt a comparatively larger diameter for single than for twin screws; that is, one more than equal to the combined disc area of the two.

4.—Immersion of Propellers.

The importance of sufficient immersion of screws is well known, a considerable loss of efficiency always resulting when air is taken down in

any large quantity. Yet there can be no doubt that absolute size gives a disproportionate advantage in this connection.

The 2 inch propeller used by Prof. Osborne Reynolds in the experiments described in *Trans. I.N.A.*, Vol. XV., raced severely when its blades tipped the surface of the water. A 20 feet propeller will not be affected to anything like that extent in corresponding circumstances, evidently because it cannot draw down so much air in proportion to its size.

Revolutions and slip per cent. appear to be increased, at a given speed, in proportions approaching the values in the following table, where H is the distance from centre of screw to the surface of wave when under weigh, average immersion being taken at 0·3 diameter, and the thrust remaining constant :—

$\frac{H}{D}$.	Revolutions per Minute.
1·3	100
1·2	102·5
1·1	105
1·05	107·5

5.—Frictional Resistance of Screws.

The coefficients of friction for various surfaces published by the late Dr. Froude in 1872 have been practically confirmed by the independent experiments of Tideman.

Prof. Greenhill has given an exact analysis in the *Engineer*, July 9th, 1886, of the frictional element, in the course of his series of papers upon the screw propeller.

Unless calculating between propellers widely differing in size, no appreciable error will be introduced by simply merging this factor into the main quantity subject to the law of comparison. This course may often be all the more advantageous, as it is still uncertain how much of the surface of the blade is to be taken into account. It was found in the trials of S.S. "Iris" that the coefficient of blade friction seemed to decrease at the larger slip-ratios, apparently because the flow of water overleaps some of the back surface in these circumstances.

Assuming that both sides of the blades are equally affected, the following formula will approximately express the resistance in pounds, due to fluid friction :—

V = speed of screw in knots per hour.
D = dia. of propeller.
B = mean breadth of each blade.
P = pitch.
A = expanded surface, 1 side.

$$\text{Resistance} = \frac{\cdot 026A}{B^{\frac{1}{4}}} \times \left\{ \tfrac{3}{4} V \frac{\sqrt{\pi^2 D^2 + P^2}}{P} \right\}^2.$$

This is for painted surface. The constant can be reduced to suit any other surface, in proportion to the figures published by Dr. Froude.

6.—Edge or Head Resistance of Screw.

In propellers of similar thickness of blades this factor should follow the law of comparison, and as it is a frequent practice to make propellers with the same ratio of thickness to diameter we will frequently be able to neglect any correction on account of edge resistance.

If, however, the metal be made as thin as can be, then in similar propellers at corresponding speeds the square of the thickness of the blade will be proportional to the total thrust, or to the cube of the diameter, since—

$$t^2 \times B \propto D^3 \times r,$$

where t = thickness of section,
B = breadth of section,
r = radius of centre of effort.

Assuming, then, that the edge resistance is, within the limits of this particular case, directly proportional to the thickness of the blade,* we would have for proportionately strong blades at corresponding speeds

$$\text{Edge resistance per cent.} \propto D^{\frac{3}{2}}.$$

Absolute data on this subject are much wanted. The head resistance of the blades of H.M.S. "Iris" was assumed at 10 per cent. of the frictional resistance of the blades, and although for thicker propellers a larger allowance must be made, the excellent results obtained from screw propellers at high speeds and revolutions show that the edge resistance is apparently much less than would be deduced from Beaufoy's data and the law of "velocity squared." Although other considerations may account for this, it is difficult to believe that, say in U.S.S. "Minneapolis" and "Columbia," the frictional and edge resistance combined was much more than what is indicated in paragraphs 5 and 6. Froude's formula for the normal pressure, in fresh water, of planes moving at an angle α was, in pounds, $P = 1{\cdot}7 \sin \alpha \times \text{area} \times V^2$ (in feet per sec.).

* See paper by Lord Rayleigh, *Phil. Mag.*, 1876.

7.—Centrifugal Action.

Although when screws are properly immersed, this does not appear to exist to any appreciable amount, when it does occur, centrifugal action will also follow the law of comparison. For it will be best in accordance with our knowledge of facts, if we assume that, with similar propellers at corresponding speeds, the mass of water influenced is proportional to the cube of the diameter.

Hence if M = mass of water at radius r, and revolutions N, we have

$$\text{Centrifugal force} \propto Mr\,N^2,$$
$$\propto D^3\,r\,N^2,$$
$$\text{or at corresponding revs.} \propto D^3\,r\,\frac{1}{(\sqrt{r})^2},$$
$$\propto D^3,$$

which is in accordance with the law of comparison.*

Hence no correction will be necessary for centrifugal action where it exists.

8.—Maximum Thrust.

The application of the law of comparison is useful in showing the utmost that can be taken out of a given propeller, when attached to a particular form of ship, since the period of maximum available thrust will occur at corresponding speeds and revolutions, with similar vessels fitted with similar screws of proportionate diameter.

The hull of a vessel cannot, of course, be said to have *per se* any maximum speed so long as power can be applied to push or tow it. The so-called "limiting speed" is fixed hydrodynamically by the relation of the propeller employed to the hull. It is evident that when a limit to speed has been reached, say with a full model having a single screw, a further access of power may frequently be utilised by means of twin screws. The true nautical limit to speed depends conjointly upon the hull and propeller, and the available capacity for fuel and machinery,† considerations which do not come within the scope of this paper, but are merely mentioned to qualify the heading of the paragraph.

9.—Different Forms of Screws.

Although in applying the law of comparison it is assumed that a given type of screw is adhered to, it may be well to consider how far the change from one type to another is permissible without largely altering results.

* This theorem connects the law of comparison with centrifugal pumps.

† *Cf.* The Howell torpedo, of which the motive force is supplied through an electric conductor from shore.

Apart from turbine propellers, screws may be divided mainly into those with uniform pitch and those with varying pitch. We may further subdivide these as follows :—

(*a*) The generating line straight and perpendicular to the axis of rotation.

(*b*) The generating line straight and inclined aft. This has been supposed by some to throw the water to a focus, but consideration will show that the water cannot make much progress towards that focus. The stream lines of the ship are, however, cut at a more advantageous angle, and the blades are also thrown farther astern into less disturbed water, efficiency being often perceptibly increased thereby.

(*c*) The generating line curved and thrown back with concavity or convexity aft. The idea of a "focus" probably influences the designers of the former method, but the latter throws the larger portion of the blade into less disturbed water, and is probably, in single screws at least, the more efficient.

(*d*) The generating line may be concave in the direction of rotation, as in the Hirsch propeller. This is intended to reduce centrifugal action, which has been considered in section 7.

(*e*) Simultaneously with any of the above methods, the blades may be slightly curved forward at the tip. This has been said to decrease vibration, although it may be at the cost of efficiency.

(*f*) The pitch may increase radially, *i.e.*, from boss outwards. It appears reasonable that as little of the available power as possible should be expended close to the roots of the blades, where not so much forward thrust can result. We may, therefore, expect a small increase of efficiency when this arrangement is judiciously carried out ; and for corresponding results an equal percentage of increase should be adhered to in corresponding cases. This form was introduced by Woodcroft.

(*g*) Pitch increasing axially. Rankine recommended this form as likely to increase the theoretical maximum efficiency from 1 — slip per cent. to $1 - \frac{\text{slip}}{2}$ per cent. when the angle at the leading edge coincided with the direction of feed. But it may be urged, on the other hand, that even with a constant axial pitch, a sufficiently gradual acceleration of the water probably takes place, to avoid the hypothetical "shock" upon which Rankine based his reasoning in this particular theorem.* Whether this is so or not, the back resistance of the blades is naturally increased by this variation of pitch. †

* The supposition of shock appears to be opposed to the "stream-line" theory.

† See Taylor, *Resis. of Ships*, page 192.

(*h*) The "Thornycroft" screw has the greatest pitch about the centre of the blade, these being set back with convexity aft, as in (*c*) above. Mr. Thornycroft has pointed out the tendency of the water to "short-circuit" the blade when the pitch is excessive at the tip.

(*i*) The blades, as seen from aft, may be each symmetrically shaped, or curved to one side, with any of the above forms of spiral. Throwing them to one side away from the direction of rotation, has the effect of bringing the tip further aft into less disturbed water; but this may also be attained in the ways pointed out above.

10.—Shape of Blades.

The form of blade now generally known as the "Admiralty" type seems difficult to improve upon, but sundry alterations in the distribution of surface do not make much difference. When the diameter has to be unduly curtailed, comparatively broader tips will, of course, be advantageous.

With reference to all the types enumerated above, the percentage of difference between one form and another is not so large as to prevent a safe transition from one type to another, *provided that the diameter, pitch-ratio, and surface are suitable for the case; that the blades are as thin as is consistent with requirements, and that they are kept well back out of the dead-water.*

11.—Number of Blades.

While the choice of the number of blades will depend upon circumstances of draught and type of vessel, Mr. R. E. Froude has given the means of using data from 4 bladed screws for those with 3 and 2 blades, or *vice versa,* the indicated horse-power for a 4, 3, and 2 bladed propeller being in the ratio of 1, 0·865, and 0·65 respectively, for the same degree of efficiency; each single blade being of the same size.

12.—The Turbine Propeller.

In the turbine propeller* the rotary momentum of the race is utilised to produce forward thrust by placing fixed guide blades with suitable reverse curvature immediately abaft the revolving propeller, and enclosing both in a cylindrical casing, the propeller boss in the most improved form (Thornycroft's) being specially prolonged and formed to suit the flow of the race.

In treating turbine propellers under the law of comparison, an increased amount of surface relatively to diameter has to be dealt with.

* Introduced by Mr. Arthur Rigg in 1864.

Notwithstanding this, the turbine propeller remains effective where lightness of draught would preclude the use of an ordinary screw.

13.—Hydraulic Propulsion.

Whether actuated by a reciprocal or a centrifugal pump, the indicated horse-power of similar pumps with similar passages will, when the number of strokes per minute are inversely proportional to the square root of the linear dimensions, tend to follow the law of comparison.

In this plan, which, in spite of its low efficiency, recommends itself for application to steam lifeboats, the friction of passages will, in case of great difference of size, have to be taken into account, and will, of course, always tell to the advantage of the larger model.

14.—Paddles.

In comparing paddles with one another in this connection, it will be necessary to take note of the following causes of difference of relative performance:—

(*a*) Position and amount of immersion.

(*b*) Ratio of breadth and depth of float to diameter of paddle.

(*c*) Whether radial or feathering floats, and wooden or steel.

As a means of utilising a given amount of indicated horse-power, the paddle with feathering floats appears in smooth water to be as efficient as the screw. A considerable amount of air is drawn down by each float, but on the other hand the absence of race rotation and the great diminution of surface friction on floats as compared with screw blades, appear fully to make up the difference in a smooth sea.

The relative suitability of the paddle and the screw for particular purposes is a question that will be easily solved by those to whom it happens to present itself.

The results of a few paddles will be found on Plate VI., reduced to uniform diameter (mean).

15.—Methods of Procedure.

For the utilisation of experimental data, the writer has found convenient a sheet of logarithmically ruled paper, as explained in *Transactions*, Vol. IX. Scales representing diameter, revolutions, indicated horse-power, and speed are put down, as well as a gradient reducing speeds of one diameter to corresponding speeds of any other diameter.

A type of such a diagram is shown on Plate VI. Upon a piece of tracing paper are plotted out the trial curves or spots of indicated horse-power and revolutions of actual screws or paddles, the paper being moved into a position to correspond with the diameter, and these data, corrected

if necessary, are at once ready for estimating the diameter, indicated horse-power, speed, or revolutions of a similar propelling instrument attached to a similar ship.

The limits of speed and indicated horse-power obtainable with a given propeller and ship are, if reached, generally recognised by the deflection of the power curve towards the speed gradient.

16.—General Considerations.

It will thus be seen that whatever be the fixed conditions influencing the quantities sought for—*i.e.*, whether diameter, pitch-ratio, indicated horse-power, revolutions, speed, or any two of these be the unalterable factors in the problem—it will be apparent by this method, without calculation, whether a solution under these conditions is possible at all; and, if it is possible, what the values of the other quantities are, provided that we have a sufficient variety of experiments or trial results to fall back upon.

A few published examples are given as illustrations, and will serve to show the differences in performance of various types of ship and propeller upon the same diameter of propeller. A comparison of this nature was suggested by Mr. A. E. Jones in *Engineering*, July 3rd, 1891.

Apart from the regular effect of pitch-ratio, differences of slip and wake will account for the relative positions of some of the curves shown, while amount of surface, thickness of blades, or engine friction influences the performance of others.

The actual data of the ships and propellers will be found in the United States Naval Reports; Sir William White's papers in *Trans. I.N.A.; Engineering*, August 24th, 1891, and January 10th, 1890; *Industries*, January 20th, 1888; and *The Mechanical World*, November 15th, 1890; also in Murray's *Marine Engines*, published by Messrs. Crosby Lockwood & Sons.

One could hardly write on naval science of any sort without being indebted to the Froudes, and here the writer is obliged to Mr. R. E. Froude for permission to use his valuable constants, from which a selection of results are shown on Plate V.

In conclusion, it has not been intended in this short paper to deal with questions of analysis of motion, etc., for the discussion of which the enquirer must be referred to the authors already mentioned.

All that has been desired is to lay stress upon the general usefulness of the law of comparison in propeller design, and to point out how the factors which tend to modify the operation of that law may be dealt with.

APPENDIX I.

Reduction of Mr. Froude's Constants under the Law of Comparison.

$$O_R = \text{revs.} \times \sqrt{\text{I.H.P.}} \times \frac{1}{V^{2\cdot5}},$$

$$\therefore \frac{1}{I^{\frac{1}{2}}} \propto \frac{\text{revs.}}{V^{2\cdot5}}.$$

responding speeds and revolutions,

$$\frac{1}{I^{\frac{1}{2}}} \propto \frac{D^{-\frac{1}{2}}}{(D^{\frac{1}{2}})^{2\cdot5}},$$

$$\therefore \frac{1}{I^{\frac{1}{2}}} \propto \frac{1}{D^{\frac{3\cdot5}{2}}},$$

$$\therefore I \propto D^{\frac{7}{2}}.$$

Also $$O_D = \frac{D}{I^{\frac{1}{2}}} \times V^{1\cdot5},$$

$\therefore$ at corresponding speeds

$$I^{\frac{1}{2}} \propto D \times V^{1\cdot5},$$

$$\propto D \times (D^{\frac{1}{2}})^{1\cdot5},$$

$$\therefore I \propto D^{\frac{7}{2}}.$$

Also with Mr. Froude's Notation.

$$\text{Since } O_R = RI^{\frac{1}{2}} \times \left(\frac{1}{V}\right)^{2\cdot5},$$

$$\therefore R \propto \frac{V^{2\cdot5}}{I^{\frac{1}{2}}}.$$

Hence at corresponding speeds,

$$R \propto \frac{V^{2\cdot5}}{(V^7)^{\frac{1}{2}}},$$

$$\therefore R \propto V^{-1},$$

$$\propto (D^{\frac{1}{2}})^{-1},$$

$$\propto \frac{1}{D^{\frac{1}{2}}}.$$

Reduction of Mr. Thom's Form of Constants under Law of Comparison.

$$C_A = \text{disc area} \times \frac{V^3}{\text{I.H.P.}},$$

$$\therefore \text{I.H.P.} \propto \text{disc area} \times V^3,$$

$$\propto D^2 \times V^3;$$

or at corresponding speeds,

$$\propto D^2 \times (D^{\frac{1}{2}})^3,$$

$$\propto D^{\frac{7}{2}}.$$

$$\text{Again } C_R = \text{revs.} \times \frac{D}{V},$$

$$\text{or revs.} \propto \frac{V}{D}.$$

Hence at corresponding speeds,

$$\text{Revs.} \propto \frac{D^{\frac{1}{2}}}{D},$$

$$\propto \frac{1}{D^{\frac{1}{2}}}.$$

In screws of similar pitch-ratio the actual velocity of any portion of the surface through the water, neglecting slip, will be proportional to

$$N\sqrt{p^2 + \pi^2 d^2},$$

where N = revs. per unit time,
p = pitch,
d = diameter at point referred to.

But in similar propellers $\frac{p}{d}$ = constant, so that the velocity will vary only as

$$N\sqrt{d^2},$$

$$\text{or as } N\,d.$$

Now this has to be made proportional to $\sqrt{d}$, so that we have

$$N\,d \propto \sqrt{d},$$

$$\text{or } N \propto \frac{\sqrt{d}}{d},$$

$$\therefore N \propto \frac{1}{\sqrt{d}}.$$

The three latter expressions may be taken as refering equally to paddles.

It is evident that when the circumferential component, the axial component, and the slip are each proportional to $\sqrt{d}$, the resultant velocity is also proportional to $\sqrt{d}$.

APPENDIX II.

SCREW PROPELLERS REDUCED TO 10 FEET DIAMETER WITH CORRESPONDING SPEEDS, REVOLUTIONS, AND SURFACE.

Name of Vessel.	Pitch Ratio.	Speed.	Total I.H.P.	Number of Propellers.	Blades in each.	Expanded Surface.	Revolutions.	Apparent Slip %
U.S.N. Philadelphia ...	1·4	16·32	$\frac{2,349}{2}$	2	3	27·34	143·4	18·2
„ San Francisco ...	1·38	16·78	$\frac{3,398}{2}$	2	3	31·59	145	15·4
„ Charlestown* ...	1·25	15·28	$\frac{1,986}{2}$	2	3	39·1	135·1	*(Speed by log)
„ Baltimore	1·37	16·67	$\frac{2,682}{2}$	2	3	27·2	139·4	18·5
„ Newark	1·3	15·77	$\frac{2,355}{2}$	2	3	25·1	152·4	20·1
„ Concord	1·25	15·32	$\frac{2,816}{2}$	2	3	24	155·34	20·4
„ Vesuvius	1·2	23·93	$\frac{9,548}{2}$	2	3	28·4	236	14·8
„ Minneapolis...	1·54	19·37	2,225	(C)	3	27·2	156	17·65
	1·47	18·68	1,581	3 (S)	3	23·9	162·4	20·8
	1·47	18·68	1,587	(P)	3	23·9	161·3	19·38
„ Columbia ...	1·54	19·16	1,794	(C)	3	27·2	150·6	15·85
	1·43	18·47	1,592	3 (S)	3	23·9	163·5	19·82
	1·43	18·47	1,340	(P)	3	23·9	162·1	19·13
„ Yorktown	1·19	16·49	$\frac{3,110}{2}$	2	3	23·1	168	16·46
H.M.S. Warrior	1·22	9·04	237	1	4	19·3	84·6	10·6
„ Collingwood ...	·96	12·28	$\frac{1,052}{2}$	2	4	27·0	119·3	—8
„ Swiftsure	1·22	9·74	434·3	1	2	34·25	96·4	16·8
„ Iron Duke	1·15	10·66	$\frac{829·6}{2}$	2	2	38·38	103·9	8·99
„ Bellerophon ...	·85	9·21	326	1	2	38·02	114·7	4·73
Torpedo Boat	1 375	26·88	7,090	1	3	32·2	271	26·6
Lepanto	1·0	12·68	$\frac{1,302}{2}$	2	3	19·03	133·7	2·72
Ceram	1·44	13·4	1,158	1	4	37	120·9	22·5
Reaumur, Cargo Boat ...	1·17	8·31	302	1	4	29·48	82·8	13·38

DISCUSSION.

The VICE-PRESIDENT said he was sure they must all feel gratified by the very able paper they had just heard and the valuable information afforded. He hoped they would have no difficulty in entering heartily into the discussion. There were two points he should like to refer to, and which he did not find in the paper. He thought it would be advantageous to have information relative to the application and efficiency of twin screws, particularly to large cargo steamers. Again, he

thought it very desirable to make every effort to increase the revolutions of the engines, but in doing so he was afraid it would be necessary to decrease the diameter of the propeller, as the periphery velocity was already as great as it could be judiciously run. Of course, if they could increase the revolutions with the same efficiency, they could decrease the weight and size of their engines. He made these suggestions in the hope some gentlemen during the discussion might be able to give valuable information.

The VICE-PRESIDENT stated Mr. Young had received letters from Mr. Arthur Rigg and from Mr. Froude. He felt it would be their pleasure if he invited Mr. Young to read these letters to the meeting.

Mr. YOUNG said he would read the letters to the meeting, but as they were personal communications it must be understood that they were not intended to be published. (Letters read.)

Mr. THOMAS MUDD (Mayor of Hartlepool), who was invited to speak, said he was quite unprepared, if not totally incompetent, to discuss the paper. It was one that seemed to him that wanted taking home and studying carefully, and he did not feel at all able to offer any remarks upon the main subject of the paper. He did want, however, to add an expression of his feeling as to their indebtedness to Mr. Young in giving them this able paper. He had given them very able and excellent papers before, and this one was no exception, he thought, to the rule in point of ability, and they were all very much indebted to him for bringing it before the Institution. When one read the title of the paper on propellers one was reminded of feelings in days gone by. If they denied to him the claim of being still a young man, he should say he well remembered when he was a young man how he used to come to these papers on propellers with a greedy desire that at last he might find some golden rule by which at one stroke he could arrive at the best propeller for any given ship one had to deal with; but from then till now he had been seeking that golden rule, and life seemed too short to go through all the calculations that various authorities recommended, so that one was still thrown back very much upon one's own experience. That did not, however, detract in any way from the general value of these scientific papers, and he would repeat that the Institution was much indebted to Mr. Young.

Mr. W. G. SPENCE said he merely rose to express his indebtedness to the author for his work in placing this paper before them. He thought

it impossible to discuss an abstruse paper of this kind at the first reading. To follow Mr. Young through the by-paths of his mathematical analysis was an exceedingly difficult matter, and he thought, if they did not discuss the paper, they might have some general conversation on propellers. He was glad to see the title of the paper was "On the Application of the Law of Similarity to Marine Propellers." Personally, he had been getting very *blasé* about them, and beginning to think there was no similarity at all in marine propellers; however, he lived in hope. As a rule they had to deal with propellers from an actual practical point of view—that was from reports. They had not experimenal data, but actual data from ships, and that necessarily was so involved with other conditions connected with the machinery and the ship, that the results—well, they were not always similar, they might be mysterious, and he thought sometimes miraculous, but, at all events, they were hardly similar; in fact, what those reports suggested to him more than the similarity of propellers was that classical law of similarity in human nature which King David shadowed forth in his haste; indeed, had that potentate been accustomed to examine marine reports he might have made his remark more leisurely. On the subject-matter of the paper he was not prepared to make any comments whatever, although, as he had said, they might have some general conversation on propellers. The difficulty was to get any accurate data from ships. It was only by experimental data, either tank or progressive load trial, that they could reach any conclusion; they might by mathematical investigation, but he did not know. Judging from practical results, he would be very sceptical about it. He knew a case where a propeller had been fitted and tried, and it did very well for a considerable time, until one man undertook to improve matters by fitting his own improved propeller. This propeller was reported a distinct improvement, the speed being increased something like half a knot, and the old propeller was consigned as spare to the 'tween decks. These "improved results" continued for about two years, when another man coming on the scene proceeded to improve again by taking the original propeller from 'tween decks, fitting it into its old position, and being ignorant of its history, got another half-knot over the "improved results." He could tell dozens of stories of the same sort, but they were hardly distinctly connected with the paper.

The Vice-President—The ship came out of dry dock new painted, I suppose?

Mr. Spence—I don't know, but the propeller came out of the 'tween decks.

Mr. Wm. Menzies had no wish to criticise the paper, he was perfectly unable to do so; but as an engineer, with some years' experience, he thought he might tell them a few stories connected with propellers. When he was connected with manufacturing engineering they had three similar boats to engine, and for his own satisfaction and curiosity he put a differently shaped propeller on each boat. There was one Griffith shaped, one a kind of boomerang, and another the ordinary propeller in vogue on the Tyne in those days. These propellers were all the same diameter and pitch and area, the boats all gave the same speed, but all failed in half a knot of the guaranteed speed. The shipbuilder discovering that the propellers were not the same, and that this was evidently an experiment, set himself to design a propeller which was to get the speed (10 knots). The ships were kept waiting till one of the propellers was ready, and on trial they got half a knot less speed with the improved propeller than with the original ones. The fact was the indicated horse-power was not in the ships to drive them to the speed. Another interesting story. The Chairman asked as to anyone's experience with twin screws. He remembered one boat built on the Tyne which, on the morning of the trial trip broke an eccentric strap of one of the engines, and while someone was sent ashore for a new one, they ran the measured mile with one engine, and attained a speed of 7 knots, to the great satisfaction of the owners, of whom there were a large number, for it was agreed if she went 7 knots with one engine, the two engines would drive her 14 knots.

Mr. H. Macoll said they had a rather difficult piece of work before them, and the members seemed to be somewhat shy about discussing the subject-matter of the paper. He was rather more so than the others, as the paper took the aspect of assimilating or predicating from the results of one set or series of known sets of propellers to another of different size, but he had little doubt the proposed formula would be of considerable advantage in designing propellers. The propeller, considered by itself, was a most invaluable factor in marine propulsion, and go where one liked they would find each manufacturing engineer (and a considerable number of people who were not manufacturers) had his own particular propeller, which was considerably better than any other, and still with all their variations, taking them generally, it was astonishing to find how successful the modern propeller had been. He supposed it was in most cases the survival of the fittest, as if a propeller with a considerable amount of efficiency

was not produced by the engineer to propel the vessel, he would likely soon find his occupation departing, and in these days of keen competition even the propeller could not be overlooked. It had occurred to him from what he had observed that there was much less pitting or wasting on the back of twin screw blades than in single screws; whether or not this arose from the stream being broken by the projecting part of the keel and upper part of the aperture, and the partial vacuum at the after side of the fore post admitting the air to the propeller blades, he was not prepared to say. He remembered a vessel going to sea laden bumping on the bottom crossing the bar. Somewhere in the Mediterranean it was observed that 3 or 4 feet of the keel portion of the stern frame was gone. On the vessel's return the stern frame was removed for repairs, and as the propeller was damaged a new one was supplied, but there was no pitting observed on the blades. A few months after the vessel was again docked for repairs, and the propeller blades were very much pitted. The modern fashion of sloping the propeller blades aft at the tips was understood to assist the propulsive efficiency in going ahead, which of course was the primary function of the propeller, but there was a pretty large consensus of opinion that this arrangement did not by any means increase the effect in going astern. A shipowner on the east coast of Scotland tried the experiment of diminishing the pitch of a propeller from the boss towards the tips of the blades, and strange to say the result was about equal to the ordinary style of increasing the pitch from the boss outwards. It was further stated that the propeller gave better results going astern than the ordinary style. They heard a good deal about stream lines, and drawings were shown how nicely and gracefully the water parted at or before the bow and closed at the stern, or aft of it: the general assumption, he took it, being those stream lines were more or less in a horizontal direction, or like ordinary water-lines. He considered the line of disturbed water was more in a diagonal direction, following more the line of the ribbands than water lines. The stream lines, as usually dealt with, did not accord with the disturbances, such as diverging brow waves, and the actual direction of the replacement wave had, in his opinion, a good deal to do with some of the unexplained phenomena of the propeller. Mr. Rigg's experiments to ascertain not only the lines of pressure or direction of the water leaving the propeller, but also the direction of the water approaching the propeller, seemed to him to open out a field which promised, with carefully conducted experiments, to give some very useful data, as so far as he was

aware the experiments had only been carried out on small vessels; and with reference to the experiments with 2 inch propellers, he submitted the size was much too small, and so much out of proportion to actual propellers as to be of little practical use. Instead of these microscopic trials, what was wanted was experiments on actual vessels with different propellers. With regard to the shrinkage of the drawings, he would suggest putting on each of them a scale, say 12 inches long, and then it would be a very easy matter to allow for any contraction or expansion that might occur to the papers on which the sketches were engraved.

The VICE-PRESIDENT said he would suggest to Mr. Young and other members interested in propellers if they visited that great port of Cardiff and examined its noted "scrap heaps," they would find numbers of scientific propellers which had been designed with a certainty of increasing the speed and reducing the consumption, and wonderful reports were given as to results of first voyages, but somehow or other, as these steamers gravitated to Cardiff and dry-docked, the majority of these propellers found their way to the scrap heap and passed into oblivion.

Mr. G. WEIR said he felt very much like other gentlemen present: that before one could discuss a paper like this they would have to take it home and study it for about a month; get all the information regarding propellers of which they had the trial data, and cut them down in the same way as had been done in the paper, and before saying anything either for or against Mr. Young's method, he would like to know how these results came out in the way Mr. Young had explained them.

The VICE-PRESIDENT explained it was the usual practice for the discussion of a paper to be continued at the following meeting, after which the writer of the paper had the privilege of replying. As there were many gentlemen present that night who might not be present at the next meeting, and there had been one or two questions raised, he thought they might ask Mr. Young if he would like to make any remarks, reserving to him the right of final reply at a future meeting.

Mr. YOUNG then briefly replied.

The VICE-PRESIDENT said he felt sure he was expressing the feeling of the meeting in thanking Mr. Young for his very able and interesting paper. He hoped by the next meeting members would have time to read and study the paper, and thus enter fully into the discussion. There was one point he should like to refer to, and that was relative to the question raised by Mr. Macoll as to the corrosion of the tips of

propeller blades. It appeared to him, it was probable, the cause was due to the angle at the tip of the blades not being correct. An 18 feet diameter propeller at 60 revolutions would have a periphery speed of, say, 3,300 feet per minute. Therefore, if at this great speed tips of blades were not correct in the angle, a partial vacuum would be formed behind, and as all water contained air, the air would be given off into the vacuum, and oxygen absorbed by the damp iron, with the resulting corrosion. He now declared the discussion on Mr. Young's paper adjourned till the next meeting.

The VICE-PRESIDENT said it would be within the recollection of the members that some short time ago they had had a very able paper by Mr. Baines on "The Metric System," and that certain resolutions were passed by the Institution. The subject was one of great importance, and full of interest to all professional gentlemen. He understood Mr. Baines had important information which he desired to lay before the meeting. He felt sure he should be carrying out the wishes of the meeting by inviting Mr. Baines to address them.

THE INSTITUTION AND THE METRIC SYSTEM.

REPORT BY MR. G. H. BAINES.

Mr. G. H. BAINES (West Hartlepool) said the Vice-President had asked him to contribute to the discussion on Mr. Young's paper. He said, for obvious reasons, that was quite out of the question; but if the discussion was terminated at an earlier hour than usual, he would like the opportunity of once more referring to the subject which he had the honour of bringing before them in the spring. The Institution had at the Closing Business Meeting of last session passed unanimously a resolution recommending the adoption of the metric system of weights and measures in this country. The resolution was sent to the Select Committee of the House of Commons, through Sir Henry Roscoe, chairman of that committee. The late election caused the proceedings before that committee to be shortened very considerably, but there was time, he was thankful to say, to wind up the evidence in a sufficiently satisfactory report, which was presented to the House of Commons before it was dissolved. The report had been published, and the evidence had also been published in a blue book. He had had the pleasure of sending a copy to Mr. Duckitt for the library of the Institution in Newcastle. Anyone, either on the scientific or commercial side of their business, could have no more interesting reading than was to be got from that report. The evidence was given by about twenty witnesses, representing many different interests, (1) official, (2) commercial, (3) manufacturers, (4) trade, (5) educational, (6) professional. They were practically unanimous in favour of the change. Of the engineers examined, Mr. Alex. Siemens, Mr. Emerson Dowson, Capt. Sankey, and Sir Benjamin Baker were unanimous in its favour, and Sir Frederick Bramwell was the only one whose evidence was against the compulsory adoption of the change in this country, though he advocated that both systems be allowed to run side by side. His opposition arose chiefly from his own marvellous intellect which could take short cuts in the treatment of the complicated figures and calculations of our present methods, but such treatment would be available only to the few, though he seemed to suggest that people could be educated up to his standard. Sir Benjamin Baker, the architect of the Forth Bridge, immediately followed, and differed in the most decided manner from his friend. On the final day Lord Kelvin attended, and in a most emphatic manner bore testimony that the present was a "brain-weakening and time-wasting

system that ought to be abolished." Mr. J. C. Stevenson, chairman of the Tyne Improvement Commissioners, a chemical manufacturer, and connected with shipping, was the only member who took the opposing view. He cross-examined the witnesses with great skill, and he (the speaker) thought they should be grateful to their neighbour for having elicited all that could be said against the metric system, and yet that the evidence of those in favour had been so little shaken. Mr. Stevenson held that the British system, in which the gallon represented 10 lbs. of water, and the foot 12 inches, was the best system for English-speaking people; and all that this nation needed was to retain these three factors—pound, gallon, and feet. For multiples or fractions of them we should go upon the decimal system. The Committee, with the exception of Mr. Stevenson, agreed to report that it was desirable the metric system should immediately be legalised in this country for all purposes, and that its use should become compulsory after two years. It was also recommended that the Education Department and all educational institutions should teach the metric system, and especially that decimal fractions should be taught earlier in school life. This report had been presented to the House of Commons. In no country where the metric system had been introduced had they proposed to go back to the more complicated system. It was, however, one thing to get an expert committee to agree to something, and another thing to get an Act passed; but the Associated Chambers of Commerce were taking up the matter, and the First Lord of the Treasury (Mr. Balfour) had consented to receive a deputation on the question, with a view to the recommendation being carried out. On that deputation their President (Ald. Richardson, M.P.) and he (Mr. Baines) were going to attend. He hoped that in their individual opportunities and in their business, members would take pains to use and forward the use of the metric system.

The VICE-PRESIDENT, on behalf of the meeting, thanked Mr. Baines for the interesting information given, and said he felt sure they all desired the metric system to come into use.

The meeting then dissolved.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

TWELFTH SESSION, 1895-96.

PROCEEDINGS.

THIRD GENERAL MEETING OF THE SESSION, HELD IN THE LECTURE HALL OF THE SUBSCRIPTION LITERARY SOCIETY, SUNDERLAND, ON TUESDAY EVENING, DECEMBER 17TH, 1895.

W. THEODORE DOXFORD, ESQ., M.P., PAST-PRESIDENT, IN THE CHAIR.

THE SECRETARY read the minutes of the last General Meeting, held at West Hartlepool, on 16th November, 1895, which were approved by the members present and signed by the Past-President.

The ballot for new members having been taken, the Past-President appointed Messrs. J. M. Allan and W. Hök to examine the voting papers, and the following gentlemen were declared elected:—

MEMBERS.

Coletti, Silvio, Ship Draughtsman, 83, Park Road, Newcastle-on-Tyne.

Dalrymple, William, Jun., Engineer Draughtsman, 14, Vicarage Terrace, Sunderland.

Lewins, Frank, Engineer, Rosehill, Willington Quay-on-Tyne.

Payne, Henry Fernie, Superintendent Engineer, c/o Messrs. Henry Fernie & Sons, Rumford Street, Liverpool

Turpie, David Whyte, Ship Draughtsman, c/o Messrs. W. Pickersgill & Sons, Southwick, Sunderland.

GRADUATE TO MEMBER.

Bulmer, Frederick Charles, Engineer, 2, Graingerville North, Newcastle-on-Tyne.

ASSOCIATE.

Morton, Benjamin, Trinity House Superintendent, 29, Azalea Terrace North, Sunderland.

GRADUATES.

Chapman, John Frederick, Apprentice Electrical Engineer, 7, Devonshire Place, Jesmond, Newcastle-on-Tyne.

Cookson, John Annable, Engineer Draughtsman, 2, St. Edmund's Road, Gateshead-on-Tyne.

Laing, Bryan, Shipbuilder, Thornhill, Sunderland.

Stuart, John, Engineer Apprentice, 57, Heaton Park Road, Newcastle-on-Tyne.

The PAST-PRESIDENT said he very much regretted to say that the President (Mr. Richardson) was not able to be present that night. He regretted it all the more in that the two papers upon which discussions were expected to take place, as well as the paper to be read that night, were purely engineering papers. Had Mr. Richardson been present he would, no doubt, have been able to say something upon the subject. Unfortunately, he should have to be a silent listener to what took place.

There being no further remarks offered on Mr. W. Cross's paper, the discussion was further adjourned.

The discussion on Mr. J. Denholm Young's paper "On the Application of the Law of Similarity to Marine Propellers" was resumed and closed.

Mr. J. M. ALLAN read a paper on "An Investigation into the Forces Tending to Produce Vibration in High Speed Engines."

ADJOURNED DISCUSSION ON MR. DENHOLM YOUNG'S PAPER "ON THE APPLICATION OF THE LAW OF SIMILARITY TO MARINE PROPELLERS."

The following communication on Mr. Young's paper was submitted by the SECRETARY (Mr. Duckitt):—

DEAR MR. DUCKITT,

I think Mr. Young's paper is one of great interest. He has explained in a very clear way the important laws which connect the performance of a propeller under one set of conditions with those of a similar propeller of different dimensions under another set of conditions. Some of his remarks are well worthy of note. For example, he says: "In taking data from graduated trials at points below full speed for adaptation to full speed of another steamer a small allowance may be necessary, on account of the disproportionate friction of the two engines at corresponding powers," and the table of factors, which he gives for transforming the indicated horse-power at reduced speed to what it would be if the cylinder volume instead of the pressure were reduced, should prove very useful. I would add a caution of my own for the benefit of those employed in making progressive trials of vessels. Be careful that the engines have been running for some little time at the desired speed before you go upon the measured mile, so that the cylinders may have had time to acquire the temperature due to the mean steam pressure. It may happen that the vessel proceeds to the trial ground at say half power, and then if the engines are eased down for a slow speed run, and the mile is entered upon immediately, the power and revolutions will fall gradually through the whole run, due to the cooling of the cylinders; and unless the indicator cards happen to be taken at a moment when a fair average power is being developed—which is very unlikely—misleading results will be obtained. In the same way as the power is increased at each new series it will be found that unless time is given to allow the cylinder to heat the power and revolutions will rise while upon the knot. Mr. Young's remark also as to the greater relative loss of efficiency suffered by small propellers as compared with large ones when air is taken down is important.

Until quite recently these laws of similarity were assumed to be capable of extension to all speeds and powers, but the trials of the "Daring" last

year showed that at a certain point the laws of similarity broke down completely. A limit is set to the amount of thrust obtainable per unit of screw surface, by the fact that the only force available for causing the water to follow up the screw surface is gravity, which is an unalterable quantity. At a given distance below the surface the speed at which water will flow is definite, and depends upon the weight of the column above it. Part of the thrust of a screw is obtained by forcing water astern with the after face of the blades, and part by drawing water in the same direction with the forward face. It is this latter part of the whole thrust which depends upon the possibility of the water flowing after the screw with sufficient rapidity. As, for a given pitch-ratio and slip, the thrust of a screw per unit of area varies as the square of the speed, it follows that a point may be reached, and in fact was reached in the "Daring," when the thrust per unit of area demanded from the screw is greater than can be efficiently obtained, and it then becomes necessary to increase the ratio of blade surface to disc area in order to keep the thrust per unit of surface within the required limits. Model experiments in this case fail completely as a guide, and it is not, so far as I can at present see, possible to reproduce in a model the conditions under which the laws break down.

Yours faithfully,

SYDNEY W. BARNABY.

MR. YOUNG'S REPLY.

Mr. J. DENHOLM YOUNG, in reply, said he had to thank Mr. T. Mudd (Mayor of Hartlepool), Mr. J. R. Fothergill, Past-President, and the other speakers for their kindly reception of his paper.

The question referred to by Mr. Fothergill, of twin screws for large cargo steamers, was one which it would be difficult to give a general answer to, depending, as it did, so much upon particular conditions, especially draught and speed. The additional safety was of course obvious, while experience with twin screws seemed to have proved that on ample draught they were at least as efficient as single screws, while on limited draught they might be more so. In dealing with cargo boats, however, other considerations than that of propeller efficiency would generally decide the case.

He was sorry for Mr. Spence's despair about getting reliable data. It was often a real difficulty, no doubt, but still, trustworthy results were frequently obtainable, and could be of great service if carefully analysed and compared.

Mr. Macoll had stated that he observed less pitting on the back of the blades of twin screws than single screws. If this were a general rule it might be accounted for by the twin screws being better immersed than the single ones, and also by their being away from the line of air-bubbles which followed the stern post even at a considerable depth.

Mr. S. W. Barnaby's caution about conducting progressive trials would be greatly valued by the members, and he hoped it would not be the last time that Mr. Barnaby would give this Institution the benefit of his experience.

Mr. R. E. Froude, in the course of correspondeuce, had also laid emphasis upon the extreme point at which the law of similarity broke down, touched upon in paragraph 4 of the present paper. Mr. Froude pointed out that when "cavitation," as he had named it, behind the blades took place, thereby causing a break in the continuity of the law, it would do so, for conditions under which $\frac{T}{A V^2}$ = constant, at a certain absolute value of V, independent of the size of ship, etc.

The general consequences of the remarks immediately foregoing were these: that at extreme thrusts there was a danger in interpreting the results of a larger propeller to predict the performance of a smaller one; while on the other hand the "top" results of a smaller propeller could safely be taken as being comparatively below the breakdown point of a larger one proportionately immersed.

These occurrences, however, formed the exceptions, not the rule; and for a wide range of speeds and sizes, the law of comparison could be applied with confidence by the designer; if the maximum thrust obtainable from each model were noted, a "bounding curve" of great use could be obtained.

The writer had used this system for some years, and found it handy in drawing-office practice and for rapidly estimating the revolutions, etc., of proposed engines for vessels of given draught.

As a matter of fact, the law of similarity was more accurately fulfilled in the case of propellers than with ships, on account of the much smaller amount of skin resistance involved, such a small amount that it could in general be merged into the rest of the indicated horse-power.

It was of course not necessary to make use of the logarithmic method explained in the paper. A series of curves representing indicated horse-power and revolutions for different diameters at graduated speeds, as in the "Inglis" diagram for ships, might be preferred by many; but for comparing results, and for rapid estimation, a diagram similar to that given with this paper, and say double the size, would be easily made.

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f con out which a great deal still
He nked the members for their

A hearty vote of thanks was accorded to Mr. J. Denholm Young for his useful and instructive paper.

AN INVESTIGATION INTO THE FORCES TENDING TO PRODUCE VIBRATION IN HIGH SPEED ENGINES.

By J. M. ALLAN.

[Read before the Institution in Sunderland, on December 17th, 1895.]

At the present moment the question of the vibration produced by the propelling engines on board ship is receiving a very great amount of attention, and, in the hope that the subject may prove of interest to the members of this Institution, the writer begs to offer his views as to how the forces producing vibration should be computed.

The object of this paper is to examine the various forces acting on the crank shaft, to separate and group them so that the thrust or pull on the bearings may, for any position of crank, be known. Afterwards to split them and apply all the forces at their various positions along the shaft, and so determine the rocking or other effect produced by them.

To deal thoroughly with the matter it is desirable to consider, 1st, the effect of inertia alone, on the supposition that the engine is being driven by some external means, say, by a belt; 2nd, to modify the result so obtained to meet ordinary working conditions, where the steam used in the cylinders is the motive power.

Having got these results, the effect of fitting rotary balance weights directly opposite the crank is next considered, so as to enable a definite statement to be made regarding the benefit to be derived by fitting them.

In speaking of balance weights it must be distinctly understood that what is here said is not to be interpreted as advocating the placing of weights directly opposite the crank as being the best system for balancing an engine. It is only a compromise, and all that is now intended is to show the effect produced by such an arrangement. The case selected for consideration is that of H.M. torpedo destroyer, "Sunfish," and through the kindness of Mr. F. C. Marshall the writer is permitted to put the results before this Institution.

The number of diagrams is large, but to reduce them would be to render the steps taken in their construction less clear, and although the description of them is rather lengthy it is not difficult.

Before describing them it might be advisable to remark that these engines are of the lightest possible description, and that the bearing-frame longitudinally depends for its stiffness on the fore and aft girders, which are built in the ship.

Description of Diagrams.

Conditions.—(*a*) Inertia only, without and with revolving balance weights, and including both reciprocating and rotary parts, the motive power being applied to the crank shaft by some means externally, *i.e.*, not by the engine itself.

(*b*) Inertia as in (*a*), but combined with the steam, which is the motive power, *i.e.*, usual working conditions.

(*c*) The steam pressures used are those indicated at sea by the engines when running 350 revolutions without balance weights.

Reciprocating Parts.—These are piston, piston rod, and half connecting rod, slide valve, slide rod, link block, ahead eccentric rod, and half of radius and drag links, and air pump piston and rod.

Rotary Parts.—Crank pin and webs, half connecting rod, and balance weights, the balance weights being placed directly opposite the cranks.

Weights.—	H. Lbs.	I. Lbs.	L. Lbs.
Piston, piston rod, and half connecting rod ..	427	502	635
Slide valve, slide rod, link block, ahead eccentric rod, and half of radius and drag links ...	265	312	447
Crank pin and webs and half connecting rod ...	295	295	295
Balance weights	430	496	583

Air pump and rod and crank pin = 148 lbs. For disposition of weights on shaft see Fig. 1 (Plate VIII.).

Dimensions.—

Cylinders, $18\frac{1}{2}$, 28, 42 by 18 inches stroke.

Connecting rod, 36 inch centres $\therefore \frac{\text{crank}}{\text{conn. rod}} = \frac{1}{4}$.

Slide valves, 5 inch travel.

Slide rods, 34 inch centres $\therefore \frac{\text{ecc. crank}}{\text{ecc. rod}} = \frac{1}{13{\cdot}6}$.

Air pump, 19 inches diameter $= 3\frac{3}{4}$ inch stroke.

Air pump rod, $10\frac{1}{4}$ inch centres $\therefore \frac{\text{air pump crank}}{\text{rod}} = \frac{1}{5{\cdot}47}$.

All the forces on the diagrams are drawn to a scale of $\frac{1}{6}$ inch to the ton. The rocking moments are drawn to a scale of $\frac{1}{24}$ inch to the foot-ton.

Condition A. Without Balance Weights.

The reciprocating parts move in a straight line, and are actuated by the crank through the connecting rod. Assuming the crank velocity uniform, and crank at one of the dead points, the reciprocating masses act with full centrifugal force upon the bearings, but at any intermediate position their effect on the bearings is less than at the dead points, and at the instant when the piston attains its maximum velocity, *i.e.*, when the connecting rod is tangent to the crank circle, do not exert any pressure at all on the bearings, because they at that instant are being neither accelerated or retarded.

The power required to accelerate or retard these masses at any point of the stroke is shown by Fig. 2 (Plate VIII.). This is the usual acceleration diagram.

A B = stroke of piston.
A C = power to start masses at top.
B D = power to start masses at bottom.
E indicates point of maximum velocity.

A C and B D are calculated by the formulæ for centrifugal force, viz., ·00034 × revolutions^2 × weight × radius of crank in feet, and allowance for ratio $\frac{\text{crank}}{\text{conn. rod}}$ has been made. The point E may be calculated or found graphically. Then the curve drawn through these points represents the power necessary to be applied to the piston to accelerate or retard the reciprocating masses at any position.

To find what effort is required at the crank to produce the necessary power at the piston Fig. 3 (Plate VIII.) has been constructed. The crank circle is divided in 12 parts, and with the radius of connecting rod the corresponding positions of piston are found and marked on Fig. 2. Then the radial force on the bearing at points 1 and 7 is that shown at A C and B D in Fig. 2, but at the intermediate positions the forces indicated are those shown on Fig. 2 transmitted through the connecting rod at its various angles. Thus at point 3 the force shown is a component part of the total force applied to the connecting rod, the other part of which is expended in turning effort. Fig. 4 (Plate VIII.) gives the construction :—

F B = pull at piston.
A B and H K = pull through connecting rod.
H J = radial pull at bearing.
J K = turning effort.

The centrifugal force due to the rotary [illegible] alculated, viz., crank pin and webs and half connecting rod. This force is constant, and acts radially throughout the revolution. Add this to each force in Fig. 3, and the total radial force due to reciprocating and rotary weights for any position of crank will [illegible] represented by the dotted circumscribing lines.

The valve gear is treated in exactly the same way for the reciprocating parts, but the rotary effect of the eccentric has been neglected. The result is given by Figs. 5 and 6 (Plate VIII.).

The forces indicated round the shaft it will be observed are all radial. What, however, is required to be known are the forces acting vertically and horizontally, and which produce rocking moments at the shaft. These vertical and horizontal forces may be read off Fig. 3 (Plate VIII.), they are in fact the component part of the forces there indicated.

As they act at different positions on the length of the shaft, and vary in magnitude with every position occupied by the crank during its revolution, it is convenient to apply them all to a straight line base. Thus Figs. 7 and 7*a* (Plate VIII.) result from treating Fig. 3 (Plate VIII.) in this fashion, and Fig. 8 (Plate IX.) combines diagrams for H., I., and L.P. for corresponding positions of crank. Fig. 9 (Plate IX.) shows the valve gear and air pump diagrams treated in exactly the same way, and Fig. 10 (Plate IX.) combines the whole of the valve gear with that of air pump for corresponding positions of crank.

From the combination diagrams (Figs. 8 and 10), the forces acting at any instant in either vertical or horizontal directions may be at once read off. These are then applied to the shaft at the proper fore and aft position and placed either above or below the datum line according to the sense in which they are indicated in Figs. 8 and 10.

Fig. 11 (Plate IX.) shows the application for one position of the crank, and it is necessary to repeat it for every other selected. By this construction all the forces acting at each side of the datum line are summed, and the centre of gravity of them is the centre round which the rocking forces act.

Fig. 12 (Plate X.) is the result of all such applications during a complete revolution in a vertical direction. The rocking moment at each position, together with the forces producing it, being shown. Fig. 12*a* (Plate X.) is a similar diagram for horizontal forces.

Fig. 13 (Plate X.) is a fore and aft view of the shaft on which the varying positions of axes of rocking moments may be clearly traced during the revolution. The irregular polygonal figures indicate the

moments themselves and also the direction in which their centres pass along the shaft.

The complete results of these diagrams, representing Condition A without balance weights, are summarised below :—

	Foot-Tons.	
Mean rocking moment	= 16·48	vertically.
" " "	= 11·6	horizontally.
Moments vary between	29·5 and 3·3	vertically.
" " "	20 and 1·3	horizontally.
	Tons.	
Mean of forces producing moments ...	= 18·55	vertically.
" " " " ...	= 12·9	horizontally.
Forces vary between	27·5 and 12·15	vertically.
" " "	21·15 and 8·4	horizontally.

Condition A. With Balance Weights.

The effect of fitting the rotary balance weights is very easily seen. The speed of crank being constant, the centrifugal pull of these weights on the shaft is constant and always radial.

Take Fig. 3 (Plate VIII.) and draw a circle round it, representing the centrifugal force of the balance weight. From the forces there shown subtract or add that due to the balance weight and Fig. 14 (Plate XI.) will result. These are then drawn to a straight line base (Fig. 15, Plate XI.), and combined as in Fig. 16 (Plate XI.). The whole process is then repeated exactly as already described in the former case, and Figs. 17, 17*a*, and 18 (Plate XII.) give the result. The feature to be observed in this case is, that at one position the horizontal rocking moments disappear, and the whole of the forces at that instant act together at one side of the shaft and tend to move it bodily aside. This action of course breaks up the regular rocking motion and will be felt in the engine room, nevertheless the mere fact of introducing an irregularity may reduce the horizontal movement at the ends of the vessel. The summary for this condition being :—

	Foot-Tons.	
Mean rocking moment	= 3·47	vertically.
" " "	= 1·9	horizontally.
Moments vary between	7·55 and 1·0	vertically.
" " "	6·0 and 0	horizontally.
	Tons.	
Mean of forces producing moments ...	= 6·62	vertically.
" " " " ...	= 3·9	horizontally.
Forces vary between	14·8 and 0·7	vertically.
" " "	12·35 and 0	horizontally.
Horizontal resultant force	= 7·25	

Comparing results "without" and "with" balance weights, we find the fitting of the weights :—

		Per Cent.	
Reduces	mean rocking moments	79·0	vertically.
"	" " "	83·6	horizontally.
"	variation of moments	75·0	vertically.
"	" "	68·0	horizontally.
"	mean of forces producing moments ...	64·4	vertically.
"	" " " " ...	69·7	horizontally.
"	variation of forces	8·15	vertically.
"	" "	3·14	horizontally.

Produces a horizontal resultant of $7\frac{1}{4}$ tons.

Condition B. Without Balance Weights.

In this case (the usual working condition) steam is the motive power, and the steam pressures used are those recorded at sea when running at 350 revolutions. The indicator cards (Fig. 19, Plate XIII.) have been so corrected as to obtain the exact back pressure line, and a scale has been added by which the load, in tons, on the piston may be at once read off. These loads are transmitted from the cylinder covers, top and bottom, through the columns to the bed-plate, and tend to lower or raise it and the shaft, according as to whether the steam is below or above the piston. The load on the piston, however, is not so expended, as part of it is occupied in turning effort, the remaining portion only tending to lower or raise the shaft. Fig. 20 (Plate XIII.) represents this direct pressure. Thus the load on piston has been transmitted through the connecting rod and resolved into its component parts, and that shown is the radial one.

The load (from Fig. 19) on framing throughout the revolution is shown by Fig. 21 (Plate XIII.), which also represents Fig. 20 on a straight line base. The load on framing depends on the initial and back pressures, and is modified by points of cut-off and compression. This is clearly shown on the diagram, and the resultant obtained by subtracting the load on the piston from that on the framing gives the vertical force on the shaft due to steam pressure acting on framing and on piston. Fig. 22 (Plate XIII.) represents the horizontal forces due to steam pressure from Fig. 20. We now have the effect of the steam pressure, and we already know the effect of the inertia alone (see Fig. 7, Plate VIII.); therefore, by combining Fig. 7 and the resultant of Fig. 21 (Plate XIII.) we have the effect of steam and inertia together, and this is shown by Figs. 23 and 23*a* (Plate XIV.). By combining these for corresponding positions of crank, the forces acting at any instant in

either a vertical or horizontal direction may be at once read off (see Figs. 24 and 24*a*, Plate XIV.). These forces, together with those of the valve gear and air pump, are then applied to the shaft at the proper fore and aft position, and the moments produced by them determined in exactly the same way as already described under Condition A. Figs. 25 and 25*a* (Plate XV.) are the result for a complete revolution, and give the rocking moment at any position, together with the forces producing it.

Fig. 26 (Plate XV.) shows the axes of rocking moments. The irregular polygonal figure indicates the moments and also their path along the shaft.

The complete results for Condition B, without balance weights, summarised is :—

	Foot-Tons.	
Mean rocking moment	= 25·2	vertically.
" " "	= 20·5	horizontally.
Moments vary between	42·6 and 1·5	vertically.
" " "	38 and 6·25	horizontally.
	Tons.	
Mean of forces producing moments ...	= 29·75	vertically.
" " " " ...	= 21·96	horizontally.
Forces vary between	39·6 and 20·7	vertically.
" " "	34·0 and 12·7	horizontally.

Condition B. With Balance Weights.

To meet this case it is only necessary to combine the diagrams showing steam effect with those obtained for inertia with balance weights, *i.e.*, combine Figs. 15 (Plate XI.), 21 and 22 (Plate XIII.), and Figs. 27 and 27*a* (Plate XVI.) show the result. The combination of these for corresponding positions of crank is shown by Figs. 28 and 28*a* (Plate XVI.). The curves for rocking moments are indicated on Figs. 29, 29*a*, and 30 (Plate XVII.).

N.B.—The horizontal resultant mentioned in connection with Fig. 17*a* repeats itself in this case.

Summary for this condition is :—

	Foot-Tons.	
Mean rocking moment	= 14·1	vertically.
" " "	= 3·6	horizontally.
Moments vary between	25·75 and 1·5	vertically.
" " "	13·5 and 0	horizontally.
	Tons.	
Mean of forces producing moments ...	= 20·64	vertically.
" " " " ...	= 6·8	horizontally.
Forces vary between	28·7 and 10·	vertically.
" " "	18·25 and 0	horizontally.
Horizontal resultant force	= 10·9	

Comparing results of steam "without" and steam "with" balance weights, we find fitting the weights:—

	Per Cent.	
Reduces mean rocking moments	44·0	vertically.
" " " "	82·5	horizontally.
" variation of moments	41·0	vertically.
" " "	57·5	horizontally.
" mean of forces producing moments ...	30·6	vertically.
" " " " " ...	69·0	horizontally.
" variation of forces	4·23	vertically.
" " "	14·3	horizontally.

Produces a horizontal resultant of 10·9 tons.

These engines were tried at moorings, under steam, with and without the balance weights. The greatest vertical measurement taken at the stern of vessel, without the balance weights, was actually reduced by about 60 per cent. when the weights were on. The propeller shafts were disconnected during these trials.

In conclusion, the writer desires to tender his best thanks to his friend Mr. R. B. Armstrong for his assistance and for the great skill and care he has exercised in the construction of the diagrams.

DISCUSSION.

The Past-President said those who understood this subject would agree with him that the amount of letterpress and the time taken to read the paper bore very little comparison with the amount of time that must have been taken in preparing it. The scientific knowledge, perseverance, and labour necessary for such a paper could only be realised by those who had prepared it. Before opening the discussion, Mr. Duckitt had some letters on the subject from gentlemen not able to be present.

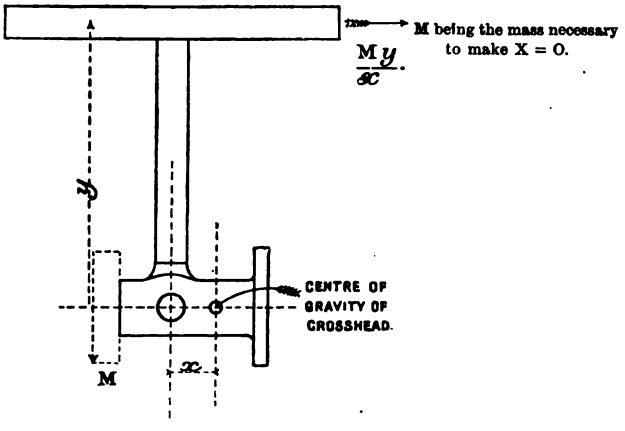
The Secretary (Mr. Duckitt) read the following communications:—

WESTMINSTER CHAMBERS,
9, VICTORIA STREET, S.W.

DEAR MR. DUCKITT,

In *re* Mr. J. M. Allan's interesting and opportune paper, I venture to suggest its value might possibly be increased if he would consider and embody the forces tending to produce vibration due to the presumably unbalanced piston rod crossheads. Lack of time and data prevent my "stating a case," but the annexed sketch illustrates the force aforesaid.

Yours faithfully,
W. CRAWFORD.



BUREAU VERITAS, 155, FENCHURCH STREET,
LONDON, E.C.,
December 16*th*, 1895.

DEAR MR. DUCKITT,

I am sure that the North-East Coast Institution of Engineers is much indebted to Mr. Allan for his interesting paper on the forces tending to produce vibration in high speed engines, and I beg to join in thanks which I am certain will be accorded to him for the same. There are only two small points to which I should like to draw his attention. The first is the statement on page 61 that the maximum velocity of piston is reached when "the connecting rod is tangent to the crank circle" (*i.e.*, when the connecting rod and crank are at right angles to each other) is not really correct, although sufficiently so for practical purposes. This fact was pointed out by *Engineering* in the review of the first edition of Mr. Holmes's book on the *Steam Engine* (March 18th, 1887, page 261), from which it will be found that the point of maximum piston velocity is slightly nearer half stroke. With the ordinary proportions of connect-

ing rod to stroke the error is very small, only equal to about 2 degs. of the crank's motion, and only about 3 degs. to 5 degs. with a connecting rod half the usual length. On Plate XVIII. A B is the connecting rod and B C the crank, at right angles to each other. Raising a perpendicular at A and producing the crank C B to meet it at D, D becomes an "instantaneous axis" to which D A and D B are radial, and the velocity of A (the end of piston rod) will be to the velocity of B (the crank pin) as D A is to D B. Taking other positions of crank $B_{,}$ and $B_{,,}$ we find that $D_{,} A_{,}$ bears a greater proportion to $D_{,} B_{,}$ than D A to D B. Making $B_{,} E_{,}$ = B D and drawing E F parallel to $A_{,} B_{,}$ we find that $A_{,} F_{,}$ is greater than A D, and the velocity of piston when crank is at $B_{,}$ greater than when it is at B. No appreciable increase is found when crank is at $B_{,,}$.

The second point is that Mr. Allan appears to have taken no notice of the dead weight or effect of gravity on the reciprocating parts. It seems to me that this should be added to the steam pressure on the down stroke and subtracted from it on the upstroke.

Yours faithfully,

J. JENNINGS CAMPBELL.

Mr. J. R. FOTHERGILL, in opening the discussion, said he found that a paper of the description they had just had the pleasure of listening to was one more suitable to the study than to general discussion without consideration. It was one that required a great deal of study before being able to discuss it in the full sense that would be required to do it justice. He took the opportunity of rising to the Past-President's invitation more especially to thank Mr. Allan for the very able paper he had put before this Institution. He congratulated the Institution, which was greatly indebted and derived great importance in the eyes of other institutions, and in the profession generally, by having such valuable papers bound in their *Transactions*. They might not at the moment be able to rise and discuss such papers with the credit they deserved, but they must all feel that having such papers in their *Transactions*, to which they could refer to, was in itself of immense value. Having no experience of high speed engines he did not himself propose to discuss this paper. His occupations were too many, and life was too short, to enter very fully into all the scientific papers brought before them, even if one were capable of doing so. The diagrams put before them, which appeared to be explicit and concise in their details, must undoubtedly be of great advantage to those who were interested in the production of high speed engines.

Mr. FOTHERGILL further remarked that he remembered Mr. Yarrow reading a very important paper before the Institution of Naval Architects. Mr. Yarrow was not a member of this Institution, but he would suggest a copy of the paper be sent to him, with an invitation to express his views.

The SECRETARY (Mr. Duckitt) said that Mr. Yarrow had had a copy sent to him, although he had not been asked for any communication.

Mr. W. STAFFORD said, like their friend, Mr. Fothergill, he could only express the indebtedness they must all feel to Mr. Allan for the very great care he had bestowed on a subject like this, and the very admirable paper he had produced. He also felt very great diffidence in criticising a paper of this description, and it was more for the purpose of furthering or inciting discussion that he just drew attention to one point that struck him in the paper—he thought there was something behind that statement in the author's mind. On page 59 he said: "In speaking of balance weights it must be distinctly understood that what is here said is not to be interpreted as advocating the placing of weights directly opposite the crank as being the best system for balancing an engine." Now, in all the high speed engines they were acquainted with there was no question that this principle was adopted, and balance weights were placed at the opposite end of the crank, seeing that in its centrifugal motion what was lost on one side of the centre was picked up or gained on the other. There was no doubt if they could invent a movable balance weight—a practicable movable balance weight that would adjust itself to the right place at the right moment—they would hit upon the proper method of balancing an engine. He just called attention to this point that it might, perhaps, suggest an idea, or might induce the author of the paper to state what was in his mind at the moment of penning the paragraph.

Mr. W. HÖK said he was not an engineer. There was just one point in almost the last paragraph that struck him. This was where Mr. Allan said: "These engines were tried at moorings, under steam, with and without the balance weights. The greatest vertical measurement taken at the stern of the vessel without the balance weights was actually reduced by about 60 per cent. when the weights were on. The propeller shafts were disconnected during these trials." He would like to ask Mr. Allan if there was any difference in amount and period of the vibrations experienced when the boat was running the mile and when she was moored, and also if there was any difference in the percentage of reduction

of vibrations due to the balance weights, when the engines were, so to speak, loaded and the propeller shafts connected, and when—the boat being moored—the engines were practically unloaded and the propeller shafts disconnected?

Mr. H. MACOLL said there was another phase of the matter which occurred to him. What was the result when both main engines happened to be giving exactly the same revolutions with the heavy portion of both engines on the down stroke? and, again, what effect had this motion when the engines synchronised with the period of the vessel's vibration? He was aboard a large Atlantic twin screw lately, and at table one of the passengers remarked, "Oh, dear me, I am afraid there must be a storm rising, and I must go on deck." The day was quiet and sea smooth. He (Mr. Macoll) had been taking note of the engines, and observed that although the engineer was careful not to have both main engines giving exactly the same revolutions, still occasionally the heavy descending stroke of both engines, with pumps, etc., would for a short time coincide, and when this did occur it set up a very disagreeable vibration or panting, and at longer intervals this panting harmonised with the ship's period, and the result of this state of matters was to make the panting quite observable to the extent of several inches in the length of the vessel. A similar, but, of course, much lesser vibration was produced when some of the ventilating or refrigerating engines happened to coincide together and also with the main engines; although under normal circumstances the vibration was scarcely perceptible.

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TWELFTH SESSION, 1895-96.

PROCEEDINGS.

FOURTH GENERAL MEETING OF THE SESSION, HELD IN THE LECTURE HALL OF THE LITERARY AND PHILOSOPHICAL SOCIETY, NEWCASTLE-UPON-TYNE, ON FRIDAY EVENING, JANUARY 17TH, 1896.

J. R. FOTHERGILL, ESQ., VICE-PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last General Meeting, held in Sunderland, on December 17th, 1895, which were approved by the members present, and signed by the Vice-President.

The ballot for new members having been taken, the Vice-President appointed Messrs. H. Macoll and A. E. Doxford to examine the voting papers, and the following gentlemen were declared elected :—

MEMBERS.

Harroway, George Mitchell, Ship Draughtsman, Philiphaugh, Wallsend-on-Tyne.

Linsley, Frederick, Engineer Draughtsman, 5, Wentworth Terrace, South Shields.

Lönnholm, Carl Gustaf A., Manager, Messrs. Oscarshamn Dry Dock Co., Oscarshamn, Sweden.

Sim, John Archibald, Ship Draughtsman, 1, South Cliffe, Roker, Sunderland.

Watson, Thomas Henry, Marine Surveyor, 10, Neville Street, Newcastle-on-Tyne.

Wilson, James, Engineer Draughtsman, c/o Messrs. Denny & Co., Engineering Department, Dumbarton.

GRADUATES.

Cole, Alfred, Apprentice Electrical Engineer, 5, Holmside, Heaton, Newcastle-on-Tyne.

Harvey, Herbert B., Apprentice Engineer, 26, Heaton Grove, Heaton, Newcastle-on-Tyne.

Leighton, James, Apprentice Engineer, 17, Eversley Place, Heaton, Newcastle-on-Tyne.

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The VICE-PRESIDENT read the following telegram from the President's office :—"Mr. Richardson is suddenly called away on important business and cannot attend meeting—much regret."

The discussion on Mr. William Cross's paper was resumed and closed.

The discussion on Mr. J. M. Allan's paper on "An Investigation into the Forces Tending to Produce Vibration in High Speed Engines" was resumed, and Mr. Allan replied.

Mr. ROBERT H. MUIR read a paper on "Countersinking in the Shipyard."

ADJOURNED DISCUSSION ON MR. WILLIAM CROSS'S PAPER "ON THE SURFACE CONDENSING PLANT."

The VICE-PRESIDENT said he had now to declare the discussion on Mr. Cross's paper open. It was heard one or two meetings ago with very great interest, and they would be pleased to hear any gentleman inclined to take up the discussion.

There being no further remarks offered, Mr. Cross was called upon to reply.

Mr. CROSS said he was afraid there was nothing very special he had to reply to. He did not know of anything further that he could say upon the paper. If any gentleman wished to ask any question or any explanation, he should be only too pleased to respond.

The VICE-PRESIDENT was sure they would all feel that a hearty vote of thanks was due to Mr. Cross for the very able paper written by him.

The vote was accorded by general approval.

ADJOURNED DISCUSSION ON MR. J. M. ALLAN'S PAPER ON "AN INVESTIGATION INTO THE FORCES TENDING TO PRODUCE VIBRATION IN HIGH SPEED ENGINES.

The VICE-PRESIDENT said Mr. Allan's paper was read at the last meeting. Many then hesitated to join in its discussion on the plea that they had not studied the paper. He hoped they had taken the opportunity, and that they would now have a good discussion.

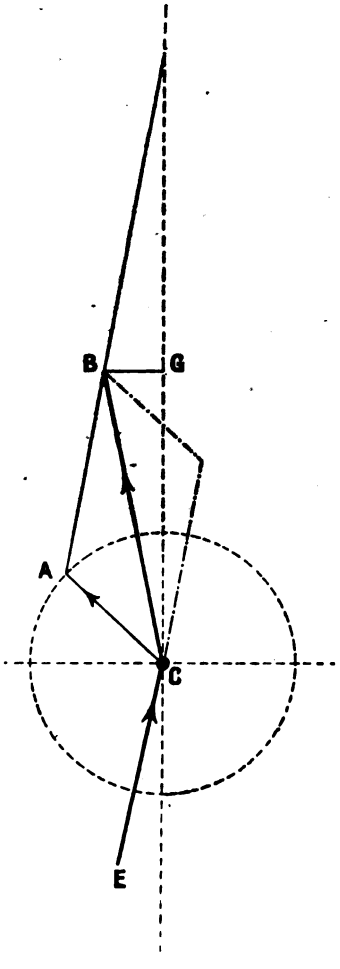
Mr. ROBERT DOXFORD said that at the Sunderland meeting, before which Mr. Allan read his paper upon "An Investigation into the Forces Tending to Produce Vibration in High Speed Engines," he hoped that someone who had given special attention to the subject would have spoken during the time allotted for the purpose. However strong his own desire might have been at the time, there was the knowledge that to convey his views to that meeting was an impossibility. Those gentlemen who availed themselves of the opportunity afforded spoke in praise of the paper, and so far as it showed the great amount of labour entailed in its production, and the praiseworthy desire of the writer to let the members of this Institution benefit by his labours, so far, he said, every credit was due. But a great deal more than evidence of labour and a praiseworthy desire was required in such a paper as Mr. Allan's to make it of value. The paper was divided by the writer into two portions—one dealing with an engine driven, and the other with an engine driving. The subject of the first portion, viz., an engine driven, had been dealt with by various writers, and among the most prominent authorities were Messrs. Yarrow, Schlick, and Rigg. The two former had read papers of a most exhaustive nature before the Institution of Naval Architects, and anyone wishing to get a fair grasp of the complicated forces under review in the first portion of Mr. Allan's paper would do well to study all the writers he had named. In Mr. Yarrow's paper alone, he would find cause, effect, and remedy, and he ventured to say, if the laws and method laid down there were followed, very little vibration, if any, would result; but he (Mr. Doxford) had never known anyone propound previously the theories set forth in the second portion of Mr. Allan's paper. They would notice Mr. Allan only claimed to have reduced vertical vibration by 60 per cent., even after fitting balance weights, 3,018 lbs. weight, which was approximately three times greater than necessary for reducing the vertical vibration

almost to zero by Mr. Yarrow's method. He was, therefore, very glad indeed that Mr. Allan, in his paper, did not advocate balance weights opposite each crank. He would now draw their attention to one or two points in the paper upon which he disagreed entirely with Mr. Allan. If they turned to page 61, and Fig. 7 (Plate VIII.), they found that to produce the figure Mr. Allan had, by Fig. 4 (Plate VIII.), resolved the vertical force necessary to give motion to the reciprocating parts along the crank and at right angles to it, and only dealt with that portion along the crank, together with the radial force due to revolving parts (both of which were shown in Fig. 3) as tending to lower and raise the bed-plate, and forgot that the force at right angles to the crank, or, as he called it, the turning effort, also had its reaction in the main bearings. By this omission he under-estimated the forces he had to deal with at all points between the dead centres and those at which the greatest turning effort existed. The vertical forces shown upon Fig. 2 (Plate VIII)., not the radial forces upon Fig. 3 (Plate VIII.), were the ones he should have dealt with. Now, if they turned to the second part of Mr. Allan's paper, the same mistake was repeated. But, to make matters worse, Mr. Allan said:—"These loads are transmitted from the cylinder covers, top and bottom, through the columns to the bed-plate, and tend to lower or raise it and the shaft, according as to whether the steam is below or above the piston. The load on the piston, however, is not so expended, as part of it is occupied in turning effort, the remaining portion only tending to lower or raise the bed-plate." And by Figs. 20 and 21 (Plate XIII.) there was no mistaking his meaning, which was that when steam was admitted to the cylinder of an ordinary engine there was always a resultant steam pressure tending to lower or raise the bed-plate except on the dead centres, and at the points where the steam pressures on the two sides of the piston were equal. Here, again, was forgetfulness upon Mr. Allan's part, for to turn a body he must have a couple. He could not avoid the third law of motion, which was "action and reaction are equal and opposite." To illustrate his meaning—when his connecting rod was exerting its biggest tangential force—and he claimed no radial force, therefore no force upon his bed-plate—he dealt with the whole steam pressure on the cylinder covers as tending to raise or lower the bed-plate, and altogether neglected the reaction in the main bearings due to the tangential force which was equal and parallel to the tangential force, thus completing the couple necessary to turn the shaft; and Mr. Allan would find upon resolving this reaction into its vertical and horizontal components, that the vertical component exactly equalled the load upon the

piston and upon the cover, neglecting of course the effect of the reciprocating and rotary parts. To take a general case in which the connecting rod was not necessarily at right angles to the crank, he (Mr. Doxford) had reproduced the Fig. 4 on Plate XIX., from which it was seen that the reaction in the main bearings due to the thrust in the connecting rod was a force equal and parallel to this thrust. And that when this reaction was resolved vertically and horizontally the vertical component was exactly equal to the load on the piston. Thus there was not the slightest chance of steam pressure in an ordinary design of engine raising or lowering the bed-plate or causing vibration thereby. Now, let them see where Mr. Allan was led by neglecting this simple elementary truth of action and reaction being equal and opposite. If they turned to Fig. 23 (Plate XIV.) they found he combined the untrue Fig. 7 (Plate VIII.) with the resultant obtained from an imaginary force in Fig. 21 (Plate XIII.), and what was the consequence? A resultant which gave two possible positions for the balance weights. For example, take the low pressure diagram, Fig 23 (Plate XIV.). The greatest upward force was shown between points 1 and 2, and the greatest downward force between 9 and 10, and these two positions made an angle of 120 degs. with one another. But a rotary balance weight had its greatest upward and greatest downward effort on the top and bottom centres respectively, or, in other words, at two positions, making 180 degs. with one another. Therefore, if they placed the balance weight in such a position as to have its greatest downward effort, viz., at A (see Fig. 20, Plate XIX.), when the forces to be balanced, according to Mr. Allan, had their greatest upward value, viz., at B, it would be 60 degs. from its proper position when the said forces had its greatest downward value, viz., at C, because the balance weight would then be at D instead of at E. It would, therefore, be interesting to know which of these two positions Mr. Allan would recommend, for in the paper the low pressure balance weight occupied neither of these positions, but one making an angle of 15 degs. with one position and 75 degs. with the other. In conclusion, he begged to thank Mr. Allan for his paper, and while not agreeing with his arguments or the results he obtained, he hoped he would take all he had said simply as friendly criticism.

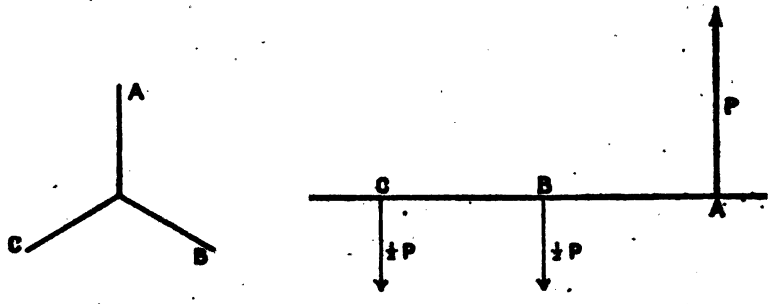
Mr. R. M. Ferrier said, like Mr. Doxford, he very much admired Mr. Allan's paper as far as regarded the labour expended. Mr. Allan must have taken an enormous amount of trouble to prepare those beautiful diagrams; but he would like to point out one or two things which did not agree with what they were accustomed to consider the

correct methods of finding the forces involved. The first point Mr. Doxford had already explained, and he did not need to dwell on it; but he should like to say he did not care for the diagram (Fig. 3, Plate VIII.) at all, it did not lead them to correct views as to the forces acting on the shaft. By neglecting the tangential effort Mr. Allan was able to get all his forces radial and then to resolve them. But as a matter of fact the forces that acted upon the shaft were not radial. Taking the crank at any angle, as at C A, they had the centrifugal force acting there along the crank in the direction C A. The pull in the connecting rod would produce an equal parallel force at C as represented by the line E C. These two forces ought to be compounded, and would produce the resultant force that would act along the line C B—not along the crank. Instead of taking the radial forces, as Mr. Allan had done in Fig. 3, and Mr. Doxford had done in the diagram he had given, he (Mr. Ferrier) preferred to reduce them to vertical and horizontal forces, as C G and B G in the sketch. The vertical forces actually exerted on the shaft at the low pressure crank were shown by the dark line in Fig. 1 (Plate XX.), while the dotted line represented the forces given by Mr. Allan (Fig. 7, Plate VIII.) This gave very much increased forces at intermediate angles, the forces being the same at the beginning and middle of the revolution. The forces on the shaft did not act along the crank, but was the resultant of two forces, and this force C B being resolved vertically and horizontally gave a vertical force equal to C G and a horizontal force equal to B G. The horizontal forces were shown in Fig. 2 (Plate XX.) by the full dark line. The dotted line gave the forces shown by Mr Allan. (Fig. 7*a*, Plate VIII.) The thin full line showed the forces which were due to the rotating parts alone, and which could be



exactly balanced by weights fixed opposite to the crank and rotating with the shaft. Fig. 3 (Plate XX.) represented the whole of the horizontal forces due to the thrust, which were very small. To show the effect on these forces of the balance weight he had thought it well to prepare the diagrams, Figs. 4 and 5 (Plate XX.), which represented the effects on the vertical and horizontal forces respectively of the balance weight, which was stated to be placed opposite to the crank. The weight was given as 583 lbs. on the low pressure crank. In Fig. 4 (Plate XX.) the thin line A represented the vertical force given by the reciprocating and rotating parts; the dotted line B represented the vertical force produced by the balance weight, and the resultant vertical force was shown by the full dark line C. This showed that the vertical forces were considerably reduced by the balance weight, but were still by no means negligible. The horizontal forces had been treated in the same way. In Fig. 5 (Plate XX.) the dotted line B represented the horizontal effect produced by the balance weight which overbalanced and produced a force of its own almost as great as the original force, which was represented by the thin line A, but in the opposite direction, and this resultant force was represented by the full dark line C. These forces were simply due to the forces produced by the inertia of the reciprocating parts and by the centrifugal forces of the rotating parts. There was one other point, not of much practical importance, certainly, in this case, but which ought not to be neglected in an exact determination of the forces produced. That was, that the weight of the moving parts sometimes assisted and sometimes opposed their action. At the high speed at which these engines were running it only amounted to somewhat less than one-twentieth of the force produced by the motion of the parts. He would like to refer also to the rocking moments fore and aft produced by the vertical forces. They were of importance. In Mr. Yarrow's paper, to which Mr. Doxford referred, he neglected the obliquity of the connecting rod, which both Mr. Schlick and Mr. Yarrow had always done in their methods of balancing the engines. By neglecting the obliquity of the connecting rod, and its effects on the forces, by making the pistons of equal weight they got rid of upward and downward force altogether, they got no vertical force at all, they had never any upward or downward force at any period of the revolution, but they still had a rocking moment produced, for the three forces were not in line. That is to say, if they took the three cranks at 120 degs. as at A, B, and C in end view of shaft (see sketch on next page), then if P be the vertical force on crank A, the vertical forces on cranks B and C were each equal to $\frac{1}{2}$ P

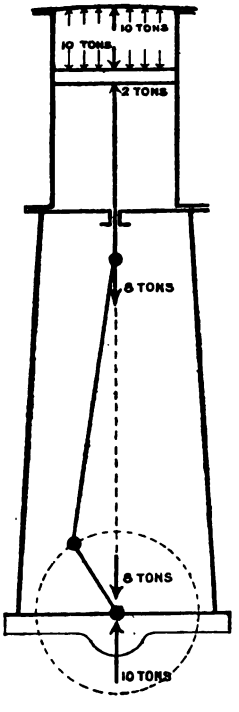
downwards, so that the total vertical force was nothing. This would be true at any point of the revolution. There was a rocking moment produced, however, which was not negligible even if they had no upward and downward force. The method of getting this rocking moment which



Mr. Allan gave in the paper is not correct. He took the line of the shaft and found at a certain point in the revolution in the figure given (Fig. 11, Plate IX.), the upward vertical force which, in this case, was 12·3 tons, and at the same point in the revolution there was also a downward force of 7·75, these being the resultant forces. In the balancing of these two forces, one single force equal to the difference might have been found by the ordinary method of moments; but not at the point given by Mr. Allan, intermediate between them. The resultant force was in the upward direction; it must be equal to the difference between these two, 4·55 tons upwards; but it would have to act to the right of the force of 12·3 tons at a distance of about 9 feet, a distance which was to be found by the ordinary method of moments. The two forces now, 12·3 and 7·75, tended to rock the engine over. The exact point about which the moments should be taken was difficult to decide. If it was a rigid body one might take it at the centre of gravity; but an engine built into a light ship like this could hardly be said to be a rigid body—perhaps it would be safer to take it at the centre of gravity of the ship. Mr. Schlick had taken it at the nodal point, where there was no vibration, but that was only found after the ship was built, and it was difficult to say where it was beforehand. The point, wherever it was, about which the moments were taken should not, however, be constantly changing, but should be always one and the same point. By the method employed in the paper the point at which the moment was taken was constantly varying, as shown in the diagram (Fig. 13, Plate X.), where the moments calculated about a different centre for each angle of crank were shown both for the vertical and horizontal directions. If the centre about which moments were taken was constantly changing,

it was impossible to compare the moments at different times. The rocking effects could only be compared when they were taken about the same point for every angle of the revolution. The last thing in the paper he wished to remark upon was that of the steam pressure producing the unbalanced forces on the engine as a whole. The steam-pressure would not produce any upward or downward force whatever if the parts had no weight. The steam pressure on the cover must be exactly balanced by the pressure on the piston, only while the pressure on the cover was transmitted by the columns to the bed-plate undiminished, the pressure on the crosshead was less than the pressure on the piston by the amount of the force required to start the piston and piston rod downwards. The difference of the upward and downward forces was equal to the vertical force produced by the inertia of the reciprocating parts as before shown by the diagram (Fig. 1, Plate XX.), just as if the engine were driven by a belt.

Mr. Doxford—Quite true.



Mr. Ferrier—If at this particular angle of the crank it took 2 tons to force the piston downward that force would not be produced by the connecting rod now, but would diminish the effect of the pressure of steam on the piston by that amount. (See sketch.) Suppose that the total pressure on piston (and on cover) was 10 tons, the result would be 8 tons downward on the cross-head, connecting rod, crank, etc., and 10 tons lifting the engine upwards. This would produce a downward pressure on the shaft of 8 tons, and the 10 tons upward would be transmitted by the columns and bed-plate to the bearing, so the resultant effect would be 2 tons, lifting the shaft exactly as before the steam pressure was applied when the engine was driven off the connecting rod, and showed the horizontal forces produced by a belt. But as it was 8 tons acting downwards at the crosshead, and not 2 tons upwards, that would be a greater force than before, which was transmitted along the connecting rod, there would be a greater horizontal force acting on the crank pin, and transmitted by the crank to the shaft. To show this effect Fig. 6 (Plate XX.) represented the curves of effective pressure

on low pressure piston given by Mr. Allan in Fig. 19 (Plate XIII.) to the same scale as the other figures, the diagram for bottom end being inverted. The inertia forces due to reciprocating parts was also taken from Fig. 2 (Plate VIII.) of Mr. Allan's paper. The actual force acting on the piston would be measured by the distance between the two curves. Fig. 7 (Plate XX.) showed the horizontal forces produced by the steam pressures, allowing for the inertia of reciprocating parts. This might be compared with Fig. 3 (Plate XX.). The horizontal forces were increased in amount: there was a greater horizontal force, taking the steam pressure into account, than before, when supposing the engine to be driven by a belt, and taking the reciprocating parts only into account, but the vertical forces acting on the engine as a whole would be exactly the same.

The VICE-PRESIDENT said he was sure they must all appreciate the able criticism they had just heard, and hoped it would be an incentive to other gentlemen to rise and freely criticise Mr. Allan's paper.

The following communications on the subject were submitted by the SECRETARY :—

QUAY STREET IRON WORKS, GLOUCESTER,

January 17th, 1896.

DEAR MR. DUCKITT,

The subject of Mr. Allan's paper to-night being very interesting to me, I hoped to be able to come to the meeting, but find at the last moment that I cannot manage to do so, may I, however, make the following remarks :—

As shown in a letter to *Engineering*, August 6th, 1886, it will be found that if r = radius of crank, c = length of conn. rod, w = angular velocity, or v = linear velocity of crank pin, φ = crank angle described from dead point and conn. rod not under four times crank, the accelerations in line of stroke are given very approximately by

$$f_L = rw^2 \left\{ \frac{r}{c} \cos 2\varphi + \cos \varphi \right\} \quad (1),$$

and the radial accelerations similarly are given by

$$f_R = rw^2 \left(\frac{r}{c} \cos 2\varphi + \cos \varphi \right) \quad \left(\cos \varphi - \frac{r}{c} \sin^2 \varphi \right) (2);$$

also that (1) gives parabolic curves in Mr. Allan's Fig. 2 (Plate VIII.), their vertices being at D, and thus the curve at D is much flatter than shown, in fact like the diagram enclosed (Plate XXI.).

The "lobe" diagrams also should be different, the lower lobe or that belonging to bottom half of stroke being flatter at lower part. I believe the above will be found correct. In the letter mentioned above it is also shown (I think correctly) that the smallest mean radial pressure on main bearings is attained by balancing half the reciprocating weight (in addition of course to the whole of the revolving weight).

It may be noted that the portion of connecting rod to be called revolving weight is not *half the weight*, but the *weight* of the *half length* adjacent to crank pin.

It can be shown that if the revolving weight and the reciprocating weight are respectively equal for all cylinders of a three-crank or four-crank engine with equal crank angles, then there is no resultant force, but only couples.

In Fig. 11 (Plate IX.) there is really not an axis of moment, but the two resultants shown can be replaced by a single force beyond the greater one, and acting in same direction; whether this single resultant causes a rocking moment on engines depends upon the position of their centre of mass.

I would venture to say that the steam pressure on piston and covers and the consequent pressure on bearings are all *internal*, and *no* direct or rocking forces can result, as appears to be stated by Mr. Allan, the only external effect on engines resulting from steam pressure is the twisting effect or couple of the propeller. I could add a few further remarks for the *Transactions* if acceptable. Hoping you will have a good meeting.

Yours faithfully,

WILLIAM SISSON.

RUTHERFORD COLLEGE, NEWCASTLE-ON-TYNE,

December 16*th*, 1895.

DEAR MR. DUCKITT,

I very much regret being unable to attend the discussion on Mr. Allan's paper, but having carefully studied it, desire to make a short criticism upon it. Although admiring the great pains spent upon it, I cannot help differing almost entirely from the results obtained; the forces that require balancing are, according to Mr. Allan, the steam pressure, the inertia of the reciprocating parts, and the centrifugal force of the rotating parts.

In the opinion of Prof. Cotterill, the steam pressure does not require balancing at all. I quote the following from his *Applied Mechanics*, chap. xi., sec. 142:—

"When the machine is at rest the forces, being all in pairs, balance each other, and have no tendency to move the machine as a whole. For example, in a direct-acting vertical engine the driving link is the steam, pressing with equal force, one way on the cylinder cover and the other way on the piston; the working link is the resistance to turning of the crank shaft, which exerts equal and opposite forces, one way on the crank and the other on the frame which carries the shaft bearings. The steam pressure and the working resistance may each be described as a stress. The forces which make up the stress are transmitted from the piston through the connecting rod to the crank, and in the opposite direction from cylinder cover through the frame to the crank shaft. The horizontal pressure of the crosshead on the guide bars is in like manner balanced by the equal horizontal thrust of the connecting rod on the crank pin, combined with the moment of the working resistance.

So in every machine when at rest or moving slowly and steadily, the stress is transmitted from the driving pair to the working pair, not only through the movable parts of the machine, but in the opposite direction through the framing."

Taking the second part, the forces produced by the reciprocating parts, and turning to sec. 144 of the same work, we find the following:—"Stability of machines. Balancing. In a machine with reciprocating parts the balance of forces is destroyed by their inertia when the machine is in motion. The straining action on these fastenings will now be briefly considered. Taking the case of a direct-acting horizontal engine, let P be the total pressure of the steam on the cylinder cover, then the pressure P′ transmitted to the crank pin is not equal to P, but there is a difference S given by the formula—

$$S = P - P' = \frac{W\,V_o^2}{ga^2}\,x,$$

where x is the distance from mid-stroke, W the weight of the reciprocating parts, V_o the velocity of the crank pin in feet per second, and a the half-stroke; this neglects the obliquity of the connecting rod."

It follows at once from this that the force tending to displace the engine is S.

Mr. Allan has argued that only a part of S is transmitted to the shaft, and that part only of this requires balancing. I refer to the words: "Thus at point 3 the force shown is a component part of the total force applied to the connecting rod, the other part of which is expended in turning effort." And further on, after adding the centrifugal force of the rotating weights, Mr. Allan says, "What, however, is required to be

known are the forces acting vertically and horizontally, and which produce rocking moments at the shaft. These vertical and horizontal forces may be read off Fig. 3; they are, in fact, the component parts of the forces there indicated."

It appears to me that the error here arises from the fact that J K is supposed to be solely absorbed in turning, and does not produce any force on the shaft. As a matter of fact, it produces an equal and parallel force on the shaft, so that the total forces at the shaft are a vertical force equal to the inertia of the piston and rod, and a horizontal force equal to the pressure on the guides. This neglects the weight of the connecting rod. Mr Yarrow's method of balancing the moving parts by reciprocating and rotating weights, or approximately, as in a locomotive, by rotating weights, is extremely simple, and merely requires a knowledge of the principle of the lever. He also makes no attempt to balance the steam pressure.

Yours faithfully,

C. H. INNES.

MESSRS. HARLAND & WOLFF, ENGINE WORKS,

January 29*th*, 1896.

DEAR MR. DUCKITT,

I regret very much not being nearer that I might be able to attend some of the meetings of the Institution, especially the one at which Mr. Allan's paper was read, as I would have liked to have been there to ask a few questions. As I have not the slightest knowledge of what passed at the meeting, I venture to ask you to add these few remarks to the discussion, if I am not too late in forwarding them to you.

Mr. Allan says his paper is "An Investigation into the Forces Tending to Produce Vibration in High Speed Engines." He divides these forces into two series, which he deals with separately and then combined, namely, inertia forces and forces due to steam pressures on pistons.

For condition B, he says:—"The loads due to the steam pressure in the cylinders are transmitted from the cylinder covers, top and bottom, through the columns to the bed-plate, and tend to lower or raise it and the shaft according as to whether the steam is below or above the piston. The load on the piston, however, is not so expended, as part of it is occupied in turning effort, the remaining portion only tending to lower or raise the shaft."

These latter forces, due to steam pressure, I fail altogether to understand how they can be the means of producing vibration. I can understand

how they and the inertia forces affect the twisting moments on the shaft, but why Mr. Allan should bring them into calculations investigating forces producing vibration in the form of rocking endwise or swaying athwartships of the engine as a rigid structure I fail to see.

Imagine an ideal case of a set of engines worked with steam neglecting the weight of the steam, with reciprocating and rotating parts of no weight, also assuming the engine sole-plate and framing practically rigid, then in such a case there could be no vibration, as the only forces acting would be those due to steam pressures.

The forces which produce vibration are free forces acting in one direction at a time, whereas the forces due to steam pressures cannot be termed free forces.

Again, in dealing with inertia forces producing rocking or tilting, it is advisable to consider the whole of the weight of the parts acting on one side of the crank shaft that are not balanced by weights on the opposite side; for instance, the whole of the connecting rod and unbalanced part of the crank, webs, etc., the whole of the eccentrics and weights due to valve gears ahead and astern. Mr. Allan neglects astern gear for some reason.

In dealing with inertia forces tending to produce swaying thwartships, it is necessary to separate rotating and reciprocating parts, which is not such an easy matter. But when rotating and reciprocating parts are taken in combination, if the forces due to the former are balanced, then the forces due to the latter will be also. In conclusion, I wish to congratulate Mr. Allan and Mr. Armstrong on the great amount of work and care they have taken in producing these calculations and diagrams.

Yours faithfully,

BALFOUR BRAMWELL.

ISLE OF DOGS, POPLAR, LONDON, E.,
January 20*th*, 1896.

DEAR MR. DUCKITT,

Referring to your letter of the 11th and to Mr. Allan's paper, which you kindly sent me, I regret to say that at the moment I have not time to examine the paper with the care and attention which such a subject requires; but certainly, from the result of briefly examining it, I have no hesitation in saying that the matter has been most ably dealt with.

Yours faithfully,

A. F. YARROW.

MR. ALLAN'S REPLY.

Mr. ALLAN, in replying to the remarks made on his paper at the Sunderland meeting, and to the criticism which had taken place that night, said he thought he had better take the latter first. The whole of it was concentrated on why he neglected the reaction down at the shaft. It all hinged upon that point; take away that, and he thought there was nothing left. There was a reason for the course adopted; the thing had not been forgotten, but had been done with a certain motive in view, and to show he was not alone in supposing that the steam pressure was an important factor in producing vibration, and seeing they had had the opinion of various authorities quoted that night, he would give them another. If they referred to *The Engineer* of the 21st September, 1894, they would see a leading article there on the subject. In the course of that article, and in speaking of balancing the reciprocating and revolving parts of the machine it was distinctly stated that there was another very important factor to consider, and proceeds thus :—"There is another agency at work which tends powerfully to set up vertical vibration. We refer to the steam efforts on the cylinder covers. On each of these there are stresses of 5 to 30 tons, according to the size of the engines set up, and tending alternately to lift the ship up and force her down. Many persons assume that these efforts are wholly balanced and opposed in the engine room, but this is not so. The upward thrust on a top cylinder cover tending to lift the whole engine is not balanced by the downward thrust on the crank pin, save at the dead points. We have instead a couple composed of the crank pin effort, and the propeller's resistance to being turned. The effort on the cylinder covers is simple and straightforward. The way in which it is taken up is complex, and there is no room to doubt that a very potent cause of vibration is thus introduced which is not sufficiently considered." That was exactly the position he had taken, and by discounting the reaction to the turning effort at the shaft was able to show the maximum possible effect on the ship. He was not going to contradict the diagram by Mr. Doxford (Fig. 4) if it were understood that the engine was moving slowly and steadily, for with a given steam pressure they could only have a certain load, and the effect on the bearing would be the same. All resistance was due to the propeller, excluding the friction of the load, and the force necessary to generate motion in the parts. Now, supposing the propeller made large enough to absorb the whole of the load down from the engine and just to move slowly, the load upon the bearing then would be equal to that on

the piston, but might not be otherwise. Mr. Inness quoted Prof. Cotterill; but they would observe, Prof. Cotterill said, "when the machine is at rest, the forces being all in pairs, balance each other." He (Mr. Allan) was not discussing a machine at rest, but the very opposite: it was at high speed, viz., 350 revolutions. The statement above was also qualified, and was repeated as follows:—"So in every machine, when at rest or moving slowly and steadily." He did not consider the machine under notice was moving slowly, it was moving rapidly, and the number of revolutions fluctuated to a certain extent. If moving slowly and steadily, then he (Mr. Allan) granted that the downward load upon the bearing was equal to the upward load on the cover. Mr. Yarrow was quoted to show steam pressure had no effect. In his paper he said, "let us consider why an engine produces vibration. In the ordinary and vertical engine steam presses on the cylinder cover and on the piston, and from the piston the stress is transmitted to the bed-plate. Now, during the first half of the down stroke the upward pressure on the cylinder cover was greater than the downward pressure on the bed-plate to the extent of what was needed to set the reciprocating parts in motion, and this excess of upward over downward pressure lifts the engine bed and that portion of the hull to which it is attached." He (Mr. Allan) thought that was a precise though limited statement to the effect that the upward pressure tended to lift the hull. Again, consider the propeller so large that the steam load was just sufficient to cause it to revolve slowly, and that they wished to revolve it at 350 revolutions. It certainly would require a greater steam pressure to do so. Nevertheless, the resistance at the propeller would not be equal to what it would be were it blocked and brought to rest. But the steam load in each case being the same there would be less pressure upon the bearing when in motion than when at rest, and his difficulty was to fix the exact value for that, therefore to give it a regularly varying value, from *nil* at the dead points he had neglected the reaction to turning effort at the bearing. Maybe he had overstated the case; but the diagrams showed the maximum vibratory effect on the ship, and that was the reason for the course adopted.

Mr. Ferrier did not care for Fig. 3, Plate VIII., because it displayed all forces as radial, and said he preferred to reduce them to vertical and horizontal forces. The forces shown on Fig. 3 had, however, been all resolved in the directions mentioned in the diagrams which succeeded Fig. 3. On examining the diagrams produced by Mr. Ferrier a very close resemblance to those in the paper was at

once apparent. Indeed Mr. Ferrier reached the same end by another way, and which way happened, from a constructional point of view, to be not nearly so easy. Very refreshing also was the admission that steam and the reciprocating parts could possibly produce any effect in a horizontal direction. He (Mr. Allan) was glad to hear that Mr. Ferrier recognised the importance of the obliquity of the connecting rod. Mr. Ferrier seemed to have quite missed the point in connection with the rocking moment. What was shown in the diagrams was the centre of gravity of the forces acting. Had Mr. Ferrier fully thought out the matter he would have discovered many of the points obtained by the "ordinary methods of moments" to be altogether outside the ship, and therefore somewhat awkward to deal with practically. The method adopted in the paper depicted the action of these forces perfectly. Of course they could all be shown as couples, but for the present purpose it was considered better not to do so.

Mr. Crawford put a question as to the effect the unbalanced portion of the crosshead would have. It would, he thought, tend to reduce the thrust on the guide a little.

Mr. Campbell, in his letter, pointed out that the position given for maximum velocity of the piston was scarcely accurate to the extent of about 2 degs. He also says the effect of gravity on the moving parts ought to be taken into account. This was quite correct, and the latter point had been considered in the construction of the diagrams.

Mr. Fothergill's remarks were very flattering, and he thanked him for his good opinion.

Mr. Stafford asked the reason for the statement that "In speaking of balance weights it must be distinctly understood that what is here said is not to be interpreted as advocating the placing of balance weights directly opposite the crank as being the best system for balancing an engine." The reason for making the statement was that in fitting revolving weights it was necessary to consider the horizontal forces they might be able to introduce without appreciably affecting the ship. For instance, a weight might be fitted which would counteract all vertical effect of the moving parts, but it might create horizontal vibration of a troublesome character, therefore it was a case of compromise as to how much they could take off the vertical and put into the horizontal direction.

Then Mr. Hök asked a question: He "would like to know if there was any difference in the vibration of the vessel when she was steaming at moorings with the propeller disconnected, and at sea with the propeller on, and running at the same velocity"? He might say that when the ship

was running at sea there were no actual measurements taken, but the general feeling was that it was the same as when running with the engines disconnected at the moorings. To explain the reason was difficult. When running with the propellers disconnected at the moorings, the steam had only the moving parts to accelerate and the friction to overcome, at sea it had not only to do that, but drive the propeller. It followed, then, that the steam load was very much less at moorings than at sea. At sea the increased load was to drive the propeller, and the difference of the load at sea when driving the propeller, overcoming the friction, and generating the momentum, was equal to the difference of the load in the cylinders when at the moorings with the same velocity; and if the difference was the same, the result at the moorings and at sea might be expected to be the same, and practically was. Mr. Yarrow said he had made numbers of experiments, and always found it to be the same.

The remarks of Mr. Caws on the action of the vibratory forces on the hull were very, very good. He said he was led to think that a very important matter would be the extension of the longitudinals of the ship forming the engine seating. He (Mr. Allan) did not think that view could be too strongly insisted upon, for undoubtedly it was a most important feature. It appeared to him (Mr. Allan) if the seatings were short and abruptly stopped these forces must produce very great local straining, and vibration throughout the ship, by reason of their springing action on the ship's bottom. To get over that longitudinals were in the right direction.

Mr. Macoll mentioned about the vibratory effect of two low-pressure pistons descending together on board an Atlantic steamer on which he had recently sailed. He considered the vibration due to the difference in upward and downward pressure, for it was a well-known fact that the steam load in a cylinder of large diameter might not be great enough to generate the velocity of the moving parts. If they had three pistons, two would be dragging the third one along a certain part of its path, and the steam pressure would not be transmitted to the crank at all, thus there were so many tons lifting up the engine, and also lifting up the ship, and if both of these loads acted together upon the ship, he had no doubt they would cause the vibration Mr. Macoll had noticed.

He thought he had replied to all the gentlemen who had spoken, and thanked them for their criticism, and hoped the paper had proved of interest.

The points mentioned by gentlemen in letters forwarded since the meeting seem to have all been dealt with in replies to other gentlemen.

The VICE-PRESIDENT said he had to propose a very hearty vote of thanks to Mr. Allan for his paper, and for the reply they had heard to the discussion. It rested with those gentlemen as to whether they felt satisfied with that reply.

The vote was carried by acclamation.

COUNTERSINKING IN THE SHIPYARD.

By ROBERT H. MUIR.

[Read before the Institution in Newcastle-upon-Tyne, on January 17th, 1896.]

It is not far from the truth to say no detail of shipyard work has received less attention than countersinking, and for anyone to imagine that all yards observe the same practice is a great fallacy.

In bygone days it periodically challenged attention, but unfortunately after the immediate difficulty had been got over it fell back into oblivion, the only watchful eye being that of the riveter, whose object was to keep it as small as possible.

A committee charged with the revision of riveters' piece-work prices recently were asked to acknowledge and sanction a scale giving a certain face-measurement for the countersinks for different sizes of rivets. Should this size be exceeded, a certain extra sum to be paid for every $\frac{1}{16}$ inch over. It will not be necessary to produce the figures, suffice to say it was somewhat less than generally prevailed in the shipyard.

The writer's object in asking your attention to this detail is to solicit some definite information, and arrive, if possible, at some agreement as to what is the right angle of countersink for the different sizes of rivets and thicknesses of plates in shipyard work. They must always distinguish between shipyard and boilershop work, as many of the absurd blunders which occurred in the early days of iron shipbuilding could have been avoided by a due appreciation of the difference.

During the years 1860 to 1880 almost every yard had its own practice, very much according to the vagaries of the foreman plater. Now and again the registration societies came down severely; still, they were slow to put the seal of their approval to anything definite, leaving the builders a freedom not always wisely used. This continued until the year 1890, when Lloyd's Committee issued the sketches still appearing in their rules.

It will readily be granted the larger the countersink to be filled the more work for the riveter, therefore his contention for a less countersink, but there must be a limit. If the countersink is too large, the contraction of the rivet in cooling puts a severe strain on this part, so much so that the point may fly off, or may easily drop off if submitted to a sharp blow of a hammer, as when testing. On the other hand, if too small, a buckling strain may start the rivet or pull the point through the plate, and when once started corrosion soon sets in.

Having thus opened the question, reference may now be made to the Admiralty, registration societies, and some other proposals.

A variety of methods prevail in the Admiralty dockyards and private firms where vessels of war are built, some of these are given below :—

(*a.*) A common rule is 45 degs. for all ordinary sizes of rivets. This is simplicity itself, but it may be questioned whether it is not too large for 1 inch and $1\frac{1}{8}$ inch rivets in thick plates. (See sketch on Plate XXII.)

(*b.*) The following is worked to in one dockyard :—

Thickness of Plate.	Angle of Countersink.
$\frac{3}{8}$ inch.	64 degs.
$\frac{1}{2}$ "	54 "
$\frac{5}{8}$ "	52 "
$\frac{3}{4}$ "	52 "
$\frac{7}{8}$ "	47 "
1 "	43 "

These angles are very large, if compared with the registration societies, but are not drilled right through the plate.

(*c.*) Another dockyard practice is :—

Thickness of Plate.	Angle of Countersink.	Depth of Countersink.
$1\frac{1}{2}$ inch.	40 degs.	$\frac{7}{8}$ inch.
$1\frac{1}{4}$ "	40 "	$\frac{3}{4}$ "
$1\frac{1}{8}$ "	40 "	$\frac{3}{4}$ "
1 "	40 "	$\frac{11}{16}$ "
$\frac{7}{8}$ "	40 "	$\frac{5}{8}$ "
$\frac{3}{4}$ and $\frac{5}{8}$ "	40 "	$\frac{9}{16}$ and $\frac{7}{16}$ "
$\frac{9}{16}$, $\frac{5}{16}$, and $\frac{7}{16}$ "	50 "	$\frac{7}{16}$, $\frac{5}{16}$, and $\frac{5}{16}$ "
$\frac{3}{8}$ "	50 "	$\frac{9}{32}$ "
$\frac{1}{4}$ "	50 "	$\frac{3}{16}$ "

Plates under $\frac{1}{4}$ inch thick, countersink extends right through the plate.

Lloyd's requirements are as shown in Plate XXII. They are, diameter of rivet plus half diameter of rivet plus $\frac{1}{16}$ inch equal face-measurement. It will be observed that for any one size of rivet a separate drill is necessary for each different thickness of plate. Great difficulty would be experienced in complying with this regulation, besides leading to endless confusion. There may be two or even three different sizes of rivets in the same plate, each according to rule requiring a separate drill. It would be interesting to know how far this is complied with.

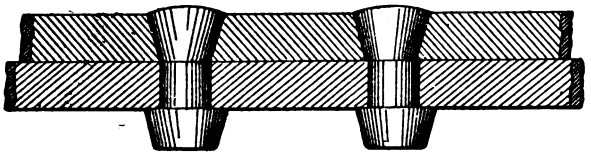
As an example, take the $\frac{3}{4}$ inch rivet, according to the riveting table it is used for all plates from $\frac{6}{20}$ to $\frac{10}{20}$ inch thick. The face-measurement of countersink being $1\frac{3}{16}$ inches: this, taken in conjunction with the requirement that the countersink must be right through the plate, shows the number of drills required. It may be seen more clearly if shown thus:—

Diameter of Rivet.	Thickness of Plate.	Face-measurement of Countersink.	Angle.
Inch.	Inch.	Inches.	Degs.
$\frac{3}{4}$	$\frac{6}{20}$	$1\frac{3}{16}$	60
$\frac{3}{4}$	$\frac{7}{20}$	$1\frac{3}{16}$	55
$\frac{3}{4}$	$\frac{8}{20}$	$1\frac{3}{16}$	50
$\frac{3}{4}$	$\frac{9}{20}$	$1\frac{3}{16}$	45
$\frac{3}{4}$	$\frac{10}{20}$	$1\frac{3}{16}$	40

showing a range of 20 degs. in the angle.

The writer is not of those who think the workers incapable of comprehending the above; on the other hand, he is not of those who think nothing is right unless accompanied with a complicated formula. What is desired is theory and science made practical. The worker, once he has got the idea, depend upon it, will, with his foot rule, very soon reach the point of the theorist.

The question of whether the countersink should be through is worthy of consideration. Many maintain it is better to stop short of through by $\frac{1}{16}$ or $\frac{1}{8}$ inch according to thickness of plate.



The best reason for putting the drill through is, should the holes not be quite opposite each other, as shown in sketch, they are more easily drifted. Quite a valid reason from a riveter's point of view.

For Bureau Veritas requirements see article 27 of their book. Rivets and riveting:—"The countersinking of the outside plating and stringer plates to be made by drill and to extend at least two-thirds through the thickness of the plates;" no angle of countersink or face-measurement is given.

For British Corporation see section 21 of their book:—" Countersink is in all cases to be extended through the full depth of hole, and the face diameter is to be in accordance with Table 14."

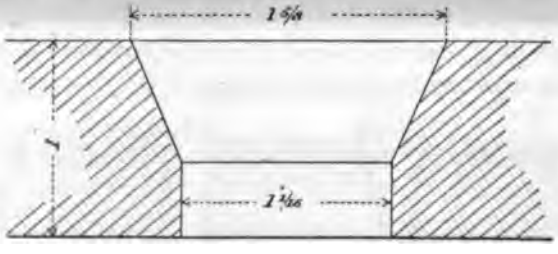
The table is simply the diameter of the rivet plus half the diameter of the rivet equal the face-diameter of the countersink. (See table at foot and Plate XXII.)

A custom which prevails in certain yards is to make a template to the angle 31 degs. Lloyd's sketch for the $1\frac{1}{8}$ inch diameter rivet, and make all the drills from this template. It will be found this does not vary much from the figured dimensions; it simplifies matters, and has its advantages. Example, the thickness of plate shown on Lloyd's sketch is $\frac{13}{16}$ or $\frac{16}{20}$ inch, angle of drill 31 degs. if the thickness of plate be increased to 1 inch, the face-measurement would be $1\frac{14}{16}$ inch against $1\frac{12}{16}$ inch or $\frac{2}{16}$ inch greater. Similarly, in the thinner plates the face-measurement would be less than given, and if used for very thin plates, say $\frac{3}{16}$ or $\frac{4}{16}$ inch, the angle would be much too small.

Another way of treating Lloyd's rule is to make a template to the angle produced by spotting off the face-measurements for $1\frac{1}{8}$, 1, $\frac{7}{8}$, $\frac{3}{4}$, and $\frac{5}{8}$ inch rivets. This angle is 38 degs.

A common custom before Lloyd's issued their tables was diameter of rivet plus $\frac{3}{8}$ inch. (See Plate XXII.)

Boilershop practice is to countersink the plate fully half through and use a much greater angle; thus, in 1 inch plates the countersink is only

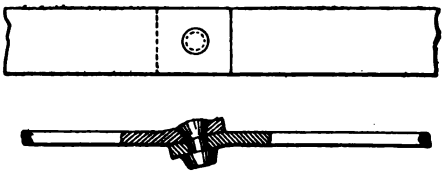


$\frac{5}{8}$ inch deep, the angle is 55 degs., and the face-measurement is $1\frac{5}{8}$ inches. (See sketch.)

Face-measurements and Angles.

Diameter of Rivet.	Thickness of Plate.	Admiralty.		Lloyd's.		British Corporation.		Lloyd's $1\frac{1}{8}$ Angle.		Diameter + $\frac{3}{8}$ Inch.		Experiment.		Thickness of Plate.
Inch.	Inch.	Inch.	Degs.	Inch.	Degs.	Inch.	Degs.	Inch.	Degs.	Inch.	Degs.	Inch.	Degs.	Inch.
$\frac{5}{8}$	$\frac{6}{20}$	$\frac{15}{16}$	45	$\frac{16}{16}$	56	—	—	$\frac{14}{16}$	31	$\frac{16}{16}$	56	$\frac{13}{16}$	56	$\frac{1}{4}$
$\frac{3}{4}$	$\frac{6}{20}$	—	—	—	—	$1\frac{3}{16}$	56	—	—	—	—	$\frac{16}{16}$	45	$\frac{3}{8}$
$\frac{3}{4}$	$\frac{12}{48}$	$1\frac{4}{16}$	45	$1\frac{3}{16}$	40	—	—	$1\frac{1}{16}$	31	$1\frac{3}{16}$	35	—	—	—
$\frac{7}{8}$	$\frac{12}{48}$	—	—	—	—	$1\frac{5}{16}$	42	—	—	—	—	$1\frac{2}{16}$	35	$\frac{1}{2}$
$\frac{7}{8}$	$\frac{12}{48}$	$1\frac{6}{16}$	45	$1\frac{6}{16}$	$37\frac{1}{2}$	$1\frac{5}{16}$	31	$1\frac{3}{16}$	31	$1\frac{4}{16}$	28	$1\frac{5}{16}$	26	$\frac{5}{8}$
1	$\frac{12}{48}$	$1\frac{12}{16}$	45	$1\frac{9}{16}$	35	$1\frac{8}{16}$	31	$1\frac{5}{16}$	31	$1\frac{6}{16}$	21	—	—	—
$1\frac{1}{8}$	$\frac{20}{48}$	$2\frac{1}{16}$	45	$1\frac{12}{16}$	31	$1\frac{11}{16}$	28	$1\frac{12}{16}$	31	$1\frac{8}{16}$	20	—	—	—

With a view to independent investigation test pieces were prepared and experiments made under the direction of Prof. Weighton at The Durham College of Science testing machine.



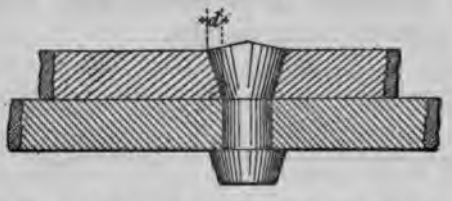
Iron Rivets.		Steel Plates.			Remarks.
Mark.	Diameter of Rivet.	Thickness of Plate.	Breaking Load per Sq. Inch.	Angle of Countersink.	
	Inch.	Inch.	Tons.	Degs.	
A	$\frac{5}{8}$	$\frac{1}{4}$	23·7	56	Rivet sheared; countersink just started.
B	$\frac{5}{8}$	$\frac{1}{4}$	24·1	40	Countersink pulled out, and head flew off at same time.
C	$\frac{5}{8}$	$\frac{6}{10}$	22·9	56	Rivet sheared in countersink (suddenly).
D	$\frac{3}{4}$	$\frac{6}{10}$	20·3	40	Countersink pulled out, and head flew off at same time.
E	$\frac{3}{4}$	$\frac{6}{10}$	22·1	35	Countersink pulled out, and rivet sheared at same time.
F	$\frac{3}{4}$	$\frac{1}{2}$	22·3	40	Rivet clearly sheared in countersink; countersink just started.
G	$\frac{3}{4}$	$\frac{1}{2}$	24·2	35	Rivet clearly sheared in countersink.
H	$\frac{3}{4}$	$\frac{1}{2}$	24·3	31	" "

NOTE.—The rivet gave way in every case, the plate being intact. The rivets seemed all sound with the possible exception of B rivet.

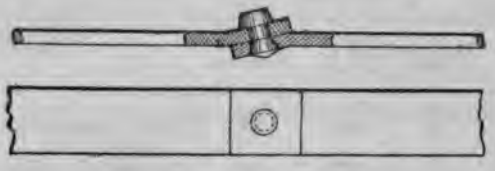
Prof. Weighton says: "Assuming the specimens were all good representatives of a class, I am inclined to draw the following deductions, viz.:—1st, for $\frac{1}{4}$ inch plates the countersink should not be less than 56 degs., and even a greater angle would seem to be not amiss. 2nd, for $\frac{1}{2}$ inch plates the countersink should not be less than 35 degs. For other thicknesses the angle of countersink would be in proportion, and therefore, 3rd, the following would be about the angles proper for the different thicknesses:—

$\frac{1}{4}$ inch plate,	56	degs.	angle	of	countersink.
$\frac{3}{8}$ "	45	"	"	"	
$\frac{1}{2}$ "	35	"	"	"	
$\frac{5}{8}$ "	26	"	"	"	

This proceeds roughly on the basis of having *d* constant." (See sketch.)



Complying with the above suggestions, specimens were prepared as under and tested as before. It will be observed the lap is set so as to put the strain more on the countersink. (See sketch.)



Iron Rivets.		Steel Plates.			Remarks.
Mark.	Diameter of Rivet.	Thickness of Plate.	Breaking Load per Sq. Inch.	Angle of Countersink.	
	Inch.	Inch.	Tons.	Degs.	
K1	$\frac{5}{8}$	$\frac{1}{4}$	22·65	56	Rivet sheared diagonally; countersink not started.
K2	$\frac{5}{8}$	$\frac{1}{4}$	23·10	56	Rivet sheared clean across; countersink not started.
L1	$\frac{3}{4}$	$\frac{3}{8}$	21·28	45	" " "
L2	$\frac{3}{4}$	$\frac{3}{8}$	27·10	45	" " "
M1	$\frac{3}{4}$	$\frac{1}{2}$	26·31	35	" " "
M2	$\frac{3}{4}$	$\frac{1}{2}$	26·88	35	" " "
N1	$\frac{7}{8}$	$\frac{5}{8}$	22·24	26	" " "
N2	$\frac{7}{8}$	$\frac{5}{8}$	21·86	26	" " "
O1	$\frac{7}{8}$	$\frac{1}{2}$	20·94	$37\frac{1}{2}$	" " "
O2	$\frac{7}{8}$	$\frac{1}{2}$	20·60	$37\frac{1}{2}$	" " "
P1	1	$\frac{5}{8}$	20·89	35	" " "
P2	1	$\frac{5}{8}$	20·50	35	" " "

These were prepared in duplicate. Marks K to N as suggested by Prof. Weighton, O and P added to Lloyd's angle.

These are all good samples. The rivet having sheared in every case, and in no case is there any sign of starting in the countersink.

Great care should be exercised in keeping the drills in good order; whenever they show signs of getting worn hollow they should be carefully

ground to standard gauges. There are many causes for irritation in the shipyard, one of the chief is to see tools being used long after they ought to have been handed over to the tool smith.

Further, too much care cannot be given to ascertain that the drills perfectly true in the bosses, otherwise the drill will take an eccentric motion, especially if the punches are faulty, taking more off one side than the other.

Again, when we consider the *modus operandi*, we come to the human element, whether it is the stationary vertical with foot strap or the improved radial arm machine, the tools perfect and working well, everything depends on the judgment of the driller, his ability to judge time; he cannot see the hole as he stands at a varying distance from it. This being so, perfect uniformity is impossible, an approximation is all we look for.

In this paper the writer affirms nothing, his desire being to ventilate the subject, and solicit discussion. Some one may say "Let sleeping dogs lie," but is that the wisest policy? We may presume there is a right and a wrong to this, as to most other things, and to do the right is just as easy, in this instance, as to do the wrong, when we have found the truth.

The writer desires to express his indebtedness to Prof. Weighton for the very careful experiments which were made at the Durham College of Science.

DISCUSSION.

The VICE-PRESIDENT said it might strike one that there was not much to say about this subject, but there was a practical interest in a paper of this description, and many of them in their experience would wish to see considerable improvement in the way holes were countersunk in shipyards. In fact, when they read these tables and saw the correct angles and sets given and knew what took place in the shipyards, he thought there was room for improvement, and gentlemen to give their practical experience.

Mr. H. MACOLL said he had not had time to consider the matter of countersinking so carefully as he would have liked. The crux of the whole matter was to find out, and do what was right, and ignore the wrong. And in this case, as in many others, it came to be, not so much the best possible, as the best practicable. As he understood the experiments in the paper,

which were very useful and to the point, still they were confined to the results of sheering stress. In the case of a lightly-plated vessel working heavily at sea there was a tendency for the plate to buckle, and go apart by breaking the rivets, or drawing them through the countersink; and experiments were also needed to demonstrate the behaviour of riveting under strains tending to pull the plates directly asunder, and he had rarely seen records of experiments carried out in that direction; of course they were much more difficult to carry out, and in their absence one could only, in the meantime, look to practice and the results of experience; and that certainly opened up a very wide field. Another phase of the matter was with great angles of countersink: the fine edges of the rivet were more liable to decay from oxidation. Speaking generally, from what he had observed, principally in repairs, rivets failed owing to their having too much angle in the countersinking, and this was more pronounced in thin plates, say under $\frac{5}{16}$ths. With plates $\frac{3}{8}$ inch thick and upwards there was, he believed, little to complain of. But there was considerable difficulty with the riveting of plates from $\frac{4}{16}$ths down. Wherever practicable he believed strongly in cupping the rivets in these thin plates, and where this was impracticable he considered that it was better to make the rivets more closely pitched than to increase the angle to any considerable extent, as by this means the work would be more easily made and maintained tight, and make more satisfactory caulking. When the rivets considerably exceeded 60 degs. in the angle, especially in thin plates, they were apt to be strained in cooling, and thus easily broken. And in his experience he had found the greatest number of what might be called original defects in the rivets were at the neck of the countersink in thin plates. In the Admiralty, so far as he understood, there was a general practice in each dockyard, but the same rule did not apply to them all, and generally 45 degs. to 52 degs. was the angle for plates of moderate thickness; and in one of the examples given there was a fixed amount of the plate left untouched by the countersinking drill, and this practice had a great deal to commend it, as there was not such an excessive difference between the diameter of rivet and the face-diameter as was attained by the ordinary practice of countersinking the plates all the way through, and this practice, he submitted, was an error, especially in the case of thick plates. One of the so-called good old ideas on this subject was to dispense with the countersinking drill entirely, by punching the outer shell plates with a large holed bolster, which made easier punching, and it must be admitted that in some cases this plan gave good results in practice. But this plan, if tried with the thinner

steel plates which are at present in use, would, he was afraid, give a very unsatisfactory result. One of the incidental advantages obtained by the use of hollow or spouted stern frames in steel was that rivets of a moderate length were used, say, 3 or 4 inches long instead of 8 to 10 inches, as in the case of a solid forging or casting; it being well known that it was impracticable to make these long rivets fill the hole solid all the way through. This was getting away somewhat from the subject. But they had as good a right to look after the one end of the rivet as the other. Considering the variety of thicknesses used in shipbuilding, it was evident that countersinking, like many other things, must be more or less of a compromise. They could not well have the drills being continually changed for each plate, sometimes having two drills for one plate, or, if so, those concerned must be prepared to find the cost of the work considerably increased over the present cost. The leading idea of the present day was more in the direction of lessening and simplifying modes of work, while anything tending to useless cost and hindrance would soon be scouted and disused, and the less complication was introduced the greater likelihood there was of getting a good job. This was conclusively shown when the attempt was made to introduce the gradation of thickness of rivets by $\frac{1}{16}$ of an inch. It might be all very well to dogmatise on such subjects, evolving the ideas of those on office stools, and there had been more trouble and annoyance endeavouring to conform to the $\frac{1}{16}$ inch gradation of rivets than anything he remembered for a long time. He considered it quite as necessary to take care there was no burr or projection between the plates or under the heads of the rivets. In this direction lay the cause of far more defective riveting than anything appertaining to the countersinking. He hoped before long to see mechanical riveting applied to the shell rivets. This would, of course, necessitate accurate countersinking, and equally accurate rivet making. Still, in these days of standard guages, electrical and other appliances for drilling and countersinking, and overhead cranes, it did not seem to be seriously outside the resources of our modern civilisation.

The discussion was at this point adjourned, and the meeting dissolved.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

TWELFTH SESSION, 1895–96.

PROCEEDINGS.

FIFTH GENERAL MEETING OF THE SESSION, HELD IN THE LECTURE HALL OF THE LITERARY AND PHILOSOPHICAL SOCIETY, NEWCASTLE-UPON-TYNE, ON FRIDAY EVENING, FEBRUARY 14TH, 1896.

ROBERT THOMPSON, ESQ., J.P., PAST-PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last General Meeting, held in Newcastle, on January 17th, 1896, which were approved by the members present, and signed by the Past-President.

The ballot for new members having been taken, the Past-President appointed Messrs. W. Mills and W. Nevins to examine the voting papers, and the following gentlemen were declared elected :—

MEMBERS.

Humble, Stephen, Jun., Engineer, c/o Messrs. Anti-Attrition Metal Company, Limited, Emerson Street, Southwark, London, S.E.

Robson, George, Engineer, 140, Aurelian Terrace, South Shields.

ASSOCIATE.

Kemp, James, Shipowner, Baltic Chambers, Newcastle-on-Tyne.

GRADUATES.

Dobson, William Gordon, Shipbuilder, The Chesters, Jesmond, Newcastle-on-Tyne.

Dodds, John Hanbury, Engineer Apprentice, c/o Mrs. Smith, North Terrace, Wallsend-on-Tyne.

Ross, William Daniel, Engineer Student, 22, Archbold Terrace, Jesmond, Newcastle-on-Tyne.

Wright, George Hudson, Electrical Engineer Apprentice, 35, Washington Terrace, North Shields.

GRADUATES' AWARD FUND FOR SESSION ELEVEN.

The PAST-PRESIDENT intimated that the amount at the disposal of the Council being £7 11s. 9d., it had been awarded as follows :—

To E. F. Moroney for paper on "Screw Propeller Shafting" ...	£2	15	0
To E. F. Baker for paper on "Steam Pipes and Fittings as found on Shipboard"	2	15	0
To Mr. A. L. Foster for his opening address	2	1	9
	£7	11	9

and explained that the money was generally spent on books, and he had much pleasure in declaring the Council's award.

The discussion on Mr. R. H. Muir's paper on "Countersinking in the Shipyard" was concluded.

Mr. M. C. JAMES read a paper on "Some Structural Details of Modern Ships."

ADJOURNED DISCUSSION ON MR. R. H. MUIR'S PAPER ON "COUNTERSINKING IN THE SHIPYARD."

The following communication from Mr. Archibald Denny was read by the SECRETARY:—

DEAR MR. DUCKITT,

Being so intimately connected with the British Corporation Registry of Shipping, it will not surprise you that I think their rule for countersinking the best, and I am strengthened in my opinion by finding on enquiry that this is the rule generally worked to by iron foremen.

It is true that some cases do occur where rivets of different sizes are used in the same plate; the differences in size are, however, as a rule, not great, and there is no serious error in using the same countersinking drill.

If a smaller angle of countersink than has been the rule could be adopted, which would ensure the plates being properly brought together, it would undoubtedly be advantageous, and reduce the labour of the riveter; but unless some good reason is brought forward for changing the practice, which has been found by long experience to be the best, I think we should

> Rather bear those ills we have,
> Than fly to others that we know not of.

As to the riveters' price list being based upon face-measurement for different sizes of rivets, I think this would be a fatal mistake. It is undoubtedly true that the work of the riveter is increased on the same size of rivet, with a larger countersink; but it appears to me it would be better to base prices upon the size of rivet in different thicknesses of plates rather than specify the face-measurement of the countersink. One can easily imagine the constant troubles there would be (intentional or unintentional) if such a rule was adopted. Countersinking is not, and never can be, practically a scientific operation, depending as it does largely upon the skill and experience of the countersinker. The ability of the rivet boy to heat the rivets properly would help or hinder the riveter's work much more than differences in countersink face area. I am not prepared to say that it would not be a good thing in thick plates to depart from the present rule of carrying the countersink entirely through the plate in preference to only partly through.

ARCHIBALD DENNY.

Mr. GEORGE N. ARNISON said in looking over this paper he thought the subject had been so well treated as to disarm discussion, for it was

difficult to say much about a paper with which one practically agreed. He thought, however, it was a pity to allow a paper to pass away without saying a few words upon it—it was not encouraging to the writer when there was little or no discussion. He thought they ought to compliment the writer upon the very clear manner in which he had treated his subject, and also for having had these experiments carried out, as they would certainly prove a valuable addition to the stock of information they had in their *Transactions*. The only point he would like to call attention to was whether it was impossible to get rid more or less of the human element in countersinking. Anyone who had had to do with the machine riveting of shell plates would know something of the different sizes of countersinks owing to this human element. It was a very awkward matter, for instance, when the riveter had got a certain length of rivet with which to fill a hole, if the countersinking were correct, that rivet filled the hole, whereas if the countersink were a little too small then the rivet was too big to fill the hole, for the point was spread over the plate necessitating it being dressed up when cold, and if the countersink were too big the rivet did not completely fill the hole. He had seen these various results in riveting garboard strakes of about an inch in thickness. A slight variation in the countersink made a considerable difference in the finish of the work. In the Government dockyards now they were employing electrical drilling machines very considerably, and it occurred to him that the solution of the difficulty he had mentioned would be realised if electrical portable drills were commercially economical, and designed so that the countersinking process would cease at the proper place by a stopping arrangement, and so give to every hole of a given size an identical countersink. He thought they were on the eve of a further development of electrical power, and makers of electrical driven tools might turn their attention to the subject of countersinking in shipyards with mutual advantage to shipbuilders and themselves. He saw in that day's *Engineer* a column about what they were doing with electrical drilling in H.M. dockyards, but he failed to see anything respecting countersinking; but if success were attained in drilling, he did not see why they should not have similar success in countersinking, and where a large amount of work was being done he thought it would prove an advantage.

The PAST-PRESIDENT said he admired Mr. Muir's paper very much for the concise way in which the information was given. He had always looked upon countersinking as one of the most important items in the

work of a shipyard. He (the Past-President) saw Mr. Muir referred, in the latter part of his paper, to the manner of countersinking. There was another matter he had noticed in his experience, that was, wherever they had to put in a big bolster and they got the countersink pretty much punched out, in that case when the countersink was put in, it barely just cleaned the hole up, and when riveted he did not think it made so strong or good a job as where the bolster was kept small and well countersunk, because the nature of the material was damaged and they did not get an uniform countersink, as the bolster wore with continual punching. They were very apt to get uneven countersink, and consequently could not get such good workmanship. With regard to electrical drilling, they did not need to go to the Admiralty to see it. He had a machine in his works both drilling and countersinking, and it had done the work very well indeed. It was made in Austria, and was certainly a very clever tool. Personally, he felt very much indebted to Mr. Muir for bringing this paper forward, for, as he had said, he thought countersinking was one of the most important details of work they had to do in putting iron or steel ships together. He thought the tables Mr. Muir had given them would have a great deal to do with the future work of countersinking. He wished some other shipbuilders had given them their experience in comparison with the statements and experiments in the paper. He was rather sorry they had not more shipbuilders present, he could not say to criticise the paper, for it was a statement of facts, but it would have added to the value of the paper had some shipbuilders given them their experience, and so either confirmed or contradicted Mr. Muir's proposed countersinks. Personally, he was very much in favour of them.

MR. MUIR'S REPLY.

Mr. R. H. Muir, in reply to the discussion, said he was greatly indebted to those gentlemen who had assisted in the procuring of facts, and to Mr. Macoll for the great interest he had taken in the paper. The other day he had a conversation with Mr. Watts, of Elswick shipyard, and while he could not give him any definite information, he said in the years 1878 and 1884 he was one of the executive staff who were entrusted by the Admiralty to scheme out countersinks. Unfortunately, the results were not to hand. Mr. Macoll in his remarks said the experiments only gave the shearing strain. Well, after a good deal of thinking all round the matter, the shearing was the only thing they could arrive at; but as they would notice from the sketches, the plates were flanged so as to

bring the pulling strain first on the countersink, and if the countersink was willing to come, it would come or start. One or two of the experiments (see experiments, marks A, B, D, and E) show the point was drawn through. These were purposely countersunk to an angle very much too small. He agreed that the failure of many rivets was the fault of too large a countersink being used, or too small. As to cracked rivets being found in repair work, there might be a few cracked rivets found in old vessels, and this was not to be wondered at. Many things contributed to it: vessels lying alongside one another in rivers or roadways, against quay walls, grounding, etc., were continually subject to bumping, all tending to crack or start rivets. It was a very common experience to find rivets cracked at the necks in old steamers. Few iron rivets would stand two blows of the hammer without flying away; he had seen hundreds cleared off as an experiment with a 7 lb. hammer. Another cause of cracked rivets was finishing off at one operation, instead of giving the rivet time to contract in cooling. The contraction helped to draw the plates together, and by knocking down another rivet in front, then going back to finish off, made a closer and tighter job. He (Mr. Muir) could not see any method in the dockyard table of angles (page 94). What they tried to arrive at in the experiments he made was to keep *d* (see sketch, page 98) constant. Professor Weighton's tables were so based, and they would see the angles came down very rapidly. He (Mr. Muir) was exceedingly obliged to Mr. Denny for his communication. As chairman of the Technical Committee of the British Corporation Registry of Shipping, his experience was wide and therefore valuable. In his remarks he said he did not think any serious error would occur from using the same drill on the same plate for different sizes of rivets. This, he (Mr. Muir) believed, was a general rule in the shipyard. They never altered the drill in passing from $\frac{3}{4}$ inch to $\frac{7}{8}$ inch, or from $\frac{7}{8}$ inch to 1 inch. If it were possible to come to an easier method of having fewer drills, there would be less liability of the men making a mistake. If the number of drills were reduced to four, he would suggest the following:—

Thickness of Plate.	Angle of Countersink.
$\frac{4}{20}$ inch to $\frac{6}{20}$ inch.	55 degs.
$\frac{7}{20}$,, $\frac{9}{20}$,,	45 ,,
$\frac{10}{20}$,, $\frac{14}{20}$,,	35 ,,
$\frac{16}{20}$,, $\frac{20}{20}$,,	25 ,,

The countersink for all plates up to $\frac{5}{8}$ inch thick to be right through, over $\frac{5}{8}$ inch, $\frac{1}{8}$ inch to $\frac{1}{4}$ inch to be left. The tool smith and countersinker should be supplied with steel plate gauges to ensure the drills being

properly made and ground. Mr. Arnison had referred to the human element; well, that was the crux of the whole matter. So far as electrical drills were concerned a countersink drill of the kind suggested, with a shoulder on it, would be a very valuable tool. He wished some of their engineers would scheme one out. He was pleased to know that Mr. Thompson had one of these electric drills, and some day he might avail himself of the opportunity of seeing it.

Mr. THOMPSON—Very pleased to show it to you.

Mr. MUIR—But why was it necessary to go to Austria for it? Punching the plates with a wide bolster could not be relied upon for watertight work; it was sure to leave a burr, besides destroying the fibre of the material round the hole. He again thanked those gentlemen who had assisted him with information, and especially Professor Weighton for his kindness in making the experiments.

The PAST-PRESIDENT had much pleasure in moving that the best thanks of the meeting be given to Mr. Muir for the valuable information he had given them.

The vote was accorded by acclamation.

ON SOME STRUCTURAL DETAILS OF MODERN SHIPS.

By M. C. JAMES, M.I.N.A.

[Read before the Institution, in Newcastle-upon-Tyne, on February 14th, 1896.]

Since the inauguration of this Institution numerous papers treating on the introduction of new types of vessels, or improvements either effected in, or proposed for, existing types, have been read and discussed at its meetings, but a retrospective glance through the *Transactions* shows that comparatively few opportunities have been afforded the members for reviewing and criticising the many changes that are constantly being introduced in the structural details of ships; indeed, the decade that has passed since the first session of this Institution was held has been a period of almost unparalleled inventive activity and progress in shipbuilding practice, and it has been particularly prolific in innovations on, and alterations in, old-established usages. Abnormally low prices have prevailed during the greater part of the time in question, and they, no doubt, to a large extent have been the exciting cause of these reforms. Experience has shown us that periods of depression are not without their uses, hence the weary succession of lean years and the consequent keen competition in the shipbuilding trade have apparently quickened the contriving faculties of shipbuilders, and led them to set their wits to work to devise the most economical arrangements of material and methods of work.

For the most part these alterations and developments are not of sufficient importance of themselves to demand separate papers. The writer, therefore, proposes to treat upon as many as can be done anything like justice to within the ordinary limits of a paper, believing it may fairly be assumed that a full discussion on these points would be likely to do much to further encourage the spirit of progress that has fortunately during recent years entered so largely into shipbuilding practice.

In reviewing some of the forward movements in structural arrangements it may perhaps strike those of the more ardent progressionists

that the advance has not been so great or so fast as it might have been, but there has never been among shipbuilders generally a tendency to hastily effect or adopt revolutionary or radical changes in ships' structural details. Progress has not, it must be owned, proceeded at dangerous, record-breaking, express speeds, but rather with measured, slow, yet sure steps. As the late poet laureate says, "Science moves but slowly, slowly, slowly creeping on from point to point"; but, in addition to this wisely-ordered law of gradual scientific progression, there have operated in the case of ship construction very powerful retarding influences; many of them, it is true, have been overcome and passed away with other old things, others, however, still remain, and are potent factors that have to be reckoned and dealt with whenever an attempt is made to introduce any departure from established practice in the arrangement of structural details.

As most students of the history of shipbuilding are aware, the abandonment of wood for iron as the leading shipbuilding material came about somewhat suddenly; consequently the work of building iron ships was thrown perforce into the hands of wood shipwrights, most of whom started to work in iron with a very strong prejudice against the new material; they were, besides, in an unfortunate state of ignorance as to its qualities and capabilities. It has certainly taken quite a quarter of a century to throw off the throttling incubus of some of the unmethodical, unscientific, and wasteful combinations of parts that grew into shipbuilding practice through the not-to-be-wondered-at desire on the part of the early iron shipbuilders to retain the old material as far as ever possible, and to assimilate most of the parts of the structure after the manner long established in the days of wood shipbuilding. Owing in no small measure to increased facilities for acquiring technical instruction, and to wider general knowledge, these prejudices and errors have, in time, been bit-by-bit removed; and both wood and wood shipbuilders' methods have gradually been displaced. Iron, as we know, for some years held full sway, but it has had in time to give way almost entirely to the newer material, steel. Numerous old-fashioned structural arrangements have become things of the past, the adoption of mild steel in shipbuilding having particularly facilitated and accelerated the changes; but whilst these alterations have been in progress there have been in operation all the time, and even yet to a certain extent exist, the clogging and hindering effects of the rules of the various registration societies for the building and classification of vessels. Far be it from the writer to imply that these rules have not, on the whole, been in fairly close touch with the state of shipbuilding

knowledge for the time being, but unfortunately in many quarters there prevailed for far too long a period a disposition to unquestioningly accept the provisions of the rules, to look upon the combinations and arrangements of parts contemplated and provided for therein as perfection, and to regard them as being quite beyond criticism. The natural effect of this state of things has been to foster mere unthinking repetition, to stifle originality of thought, deaden the inventive faculties, and stultify and retard progressive efforts. There has, moreover, been regularly kept by the leading registration societies a plentiful stock of cold red ink always ready to be thrown over anything at all approaching a new or novel arrangement of details not laid down or arranged for in the particular society's book of rules, which some original-minded shipbuilder might have the temerity to submit for approval. Whilst it must in fairness be granted that it is not the province of such corporations to initiate improvements, it must with equal justice be claimed that by far the greater number of the improvements in the structural details brought about in modern shipbuilding practice have only been carried into effect practically in spite of the societies, and rarely with their spontaneous concurrence; in fact the official approval has, in most instances, only been in the end reluctantly obtained through very persistent efforts on the part of those bringing forward the proposals.

Yet another brake force that has curbed most effectively any very rapid alterations or progress in structural details is to be found in the limited capabilities of the iron and steel manufacturers, which exercise a powerful confining influence on the range and extent of improvements and developments in the forms and combinations of parts of the structural members. Steel and iron manufacturers have, like shipbuilders, been moving steadily ahead, and by means of improved processes of manufacture and the adoption of more efficient machinery they have added considerably to their capabilities in the direction of supplying larger and wider plates, and a much greater variety of bar sections, at prices compatible with economical ship construction; this progress is being maintained, and even greater strides may reasonably be looked for in the future.

Having briefly drawn attention to the causes which, in the writer's opinion, have chiefly affected the development and improvements in the details of ship construction, he now proposes to present for consideration some of the leading improvements that have been introduced.

Keels.—Plain flat plate keels have been extensively adopted in preference to some of the more complicated hollow, dished, and other fanciful

forms that have been suggested, and in some rare instances adopted. Plate keels have also largely superseded the old-fashioned projecting keel (a relic of the old wood ships), whether fitted as a solid forged bar, or built up with slabs or side bars; this latter form of keel being especially objectionable on account of the costly character of the repairs in case of damage; and, of course, there is a considerable diminution in draught of water when a flat keel is adopted, though the steering is somewhat prejudicially affected in full ships.

Stems.—The ordinary forged bar section is still retained, but a scarph at the region of the load-line is frequently introduced in it, which considerably facilitates repairs in many cases of bow damage. The practice of shaping the foot of the stem bar to the form of the vessel in case of plate keels has been almost entirely abandoned in favour of a plain bar of rectangular section connected to centre intercostal plates, an arrangement which, whilst making a sounder connection in the first instance, further simplifies renewals in case of damage.

Sternposts.—One of the most marked features in connection with modern practice, is the very general adoption of the curved or cranked form of the inner or propeller post. When connected to flat plate keels, the heel pieces are not infrequently made as in the case of the stems described above, and sometimes three vertical scarphs are introduced into the stern frame, two on the after post, and one on the inner post, and they are found to lessen and simplify the repairs in case of a fractured post. A recently patented arrangement provides for fitting these scarphs horizontally instead of vertically (Fig. 1, Plate XXIII.), and it is claimed for this method of fitting the scarphs that it greatly strengthens and stiffens the sternpost.

Rudders.—Built rudders of the old style with forged iron stocks and frames plated over, with the intervening space filled in with wood or pitch, have given place to a large extent to rudders consisting of a single thick plate fitted between horizontal arms projecting from a cast steel stock; or to solid cast steel rudders. Both of these newer forms have the advantage of being free from the troublesome bow and seam rivets found in the old-fashioned built rudders. In some cases this style of rudder has caused trouble and expense owing to fractures developing in the arms or stock through faulty castings. A very common practice nowadays is to construct rudders with a horizontal coupling between the blade and the stock, just under the counter (Fig. 1, Plate XXIII.), and this, together with portable pintles, have been proved to be very convenient and labour-saving devices when the rudder requires unshipping, which operation is rendered

still less difficult by a recently patented arrangement of attaching the blade to the stock by means of a vertical instead of a horizontal coupling as shown in Fig. 2 (Plate XXIII.).

Framing.—Not a few important modifications have been adopted in connection with the system of framing; some of these have been introduced with a view of increasing the transverse strength sufficiently to allow of strong hold beams being dispensed with, and to this end web frames have been very largely adopted, and with considerable success, but in some instances they are objectionable on the score of interference with the stowage of such cargoes as timber, rails, etc., and, besides, they only afford local stiffness, forming, as the late Mr. Scott Russell so aptly puts it, "knuckles in the cane," so far as longitudinal strains are concerned; moreover, very awkward pockets are formed behind the diamond-shaped plates which cover the connection of the web plates and stringers, though this drawback has sometimes been partly got over by fitting half diamonds and a deep bar as shown on Fig. 17 (Plate XXIV.).

Another system of framing has of recent years come much in vogue, and is now being very extensively adopted in large vessels; it is what is commonly called the "deep frame" or "girder frame" system, shown in Fig. 3 (Plate XXIV.). In this arrangement, the main frame and reverse frame are of the same size, and they are lapped together transversely sufficiently to take a row of connecting rivets. Difficulty has been experienced in efficiently connecting the keelson lugs on this description of framing. Sometimes the lugs have been fitted as shown on Fig. 3 (Plate XXIV.), but there is not then sufficient landing on the reverse bar to make a satisfactory job. Another method has been to fit wider lugs with packing pieces in between the lug and reverse bar (Fig. 4, Plate XXIV.).

The difficulty can, however, be obviated and a satisfactory combination made by altering the position of the reverse bar, *i.e.*, fitting it on the inside of the main frame, as shown on Fig. 5 (Plate XXIV.), thus dispensing with filling-in pieces.

This deep system of framing possesses many advantages, the principal of which is that it affords a more uniform distribution of transverse strength than the web frames do. Although with the deep frames there is a certain amount of loss in the internal hold capacity there is practically no broken stowage, and a considerable reduction is effected in the under deck tonnage; besides, the substitution of a heavier and thicker bar for the old-fashioned small-sized reverse frame is a step in the right direction, as there is great waste and loss by corrosion on reverse frames, especially

on their fore-and-aft flanges. The wider frame gives more space for riveting the shell behind the reverse frame, and allows more room for chipping and painting, an important consideration, seeing the neglected state the back surfaces of the reverse frames are too frequently found in old ships.

Following the practice obtaining in war ship construction, Z frames (Fig. 6, Plate XXIV.) have occasionally been adopted for merchant vessels, but only to a limited extent, because this section of bar is expensive to make, at times troublesome to obtain, costly and difficult to manipulate in bending, bevelling, punching, cutting, etc., although theoretically it is a more efficient section of frame than one formed of two bars riveted together.

Channel section frames have also been used with considerable success (Fig. 7, Plate XXIV.); but there are the same objections to them, and the same hindrances to their extensive adoption that apply to the Z frames, with the additional difficulty of getting in, plying up, and holding on to the shell rivets behind the reverse flange.

Bulb angle frames are frequently used, and with very satisfactory results. They are particularly well adapted for framing in peaks, especially peak tanks, and in coal bunkers, where there is no need of the reverse flange for attaching battens, etc., and where ordinary reverse frames are found to waste with startling rapidity, particularly when they are of steel. The bulb angle section of frame can also be easily chipped and painted. In the cargo holds the absence of the longitudinal flanges of the reverses whereon to attach the cargo battens is somewhat of a drawback, though this can be partly overcome by securing the sparring to the frames by means of hook bolts (Fig. 8, Plate XXIV.). Double lugs are also required to form the keelson attachments, and the bulb angles are rather more difficult to handle in bending and bevelling than are plain angle bars.

Most shipbuilders have looked forward to a time when that theoretically perfect arrangement of framing, the longitudinal system, would be universally adopted, but practical difficulties have outweighed theoretical considerations, and this method of construction has only come to be employed in a modified form to the bottom of ships, and it would seem that we must be content to go on yet awhile building the topsides on the time-honoured transverse plan.

Beams.—Very little alteration has taken place in the forms of beams used for ships; but owing to the cheaper rate at which they can now be produced, there is at present a tendency to apply, to a much greater

extent than formerly, butterly or T bulb bars of large section for hold beams, in lieu of beams composed of bulb and angles. Double channel bars, too, are sometimes used for hold beams and beams connected to web frames.

Keelsons and Hold Stringers.—Numerous new combinations and arrangements of the component parts of keelsons have been introduced into practice; the old style of keelson formed of a single bulb plate and two angles (Fig. 9, Plate XXIV.) has been in several instances superseded by the double bulb angle section (Fig. 10, Plate XXIV.). The old-fashioned arrangement of hold stringer, consisting of a plate connected to the shell by short bars between the frames, to the reverse bar by two longitudinal bars, and its inner edge stiffened by two angle irons (Fig. 13, Plate XXIV.), has in sundry vessels given place to a simpler arrangement, such as the substitution of three larger angles in place of the four bars (Fig. 14, Plate XXIV.), or two large bulb angles, together with a thick stringer plate (Fig. 12, Plate XXIV.), and again in some rarer instances a stringer plate flanged directly to the shell plating with only one longitudinal bar connected to reverse frames and one facing angle, both fitted underneath the plate, thus giving a flush surface (Fig. 15, Plate XXIV.). Either of these modified arrangements give fewer ply for riveting. The exceptionally heavy bulb angles, however, are somewhat difficult to effectively close up in riveting, and their great width necessitates a special arrangement of rivets; they are, besides, awkward to bend and set at the ends of the ship. Flush surfaces on keelsons and stringers are very desirable, as the old H section is most objectionable on account of the channels formed by the upstanding flanges of the bars on the top side; grain, coal, etc., are apt to lodge therein, and these spaces are most difficult to clean and paint, consequently, excessive corrosion is liable to go on unchecked. Occasionally, the 'tween deck and lower deck stringer plates, instead of being scored over the frames and reverses fitted against the shell, and connected thereto by short angles, have been fitted only against the inner edge of the frames, and the connection to the shell has been effected by means of wide angle irons or flanged plates (Fig. 16, Plate XXIV.), thus entailing a considerable saving in both labour and material.

After long and strenuous efforts on the part of shipbuilders Lloyd's yielded to their representations, and eventually allowed the keelsons to be severed at the bulkheads, and attached thereto by bracket knees; thus avoiding piercing the plating of bulkheads to allow the keelson bars to pass through, and dispensing with much difficult and unreliable work.

Bulkheads.—But little alteration has taken place in the arrangement of these structures excepting as regards the stiffening, which has received considerable attention. The arrangement of the stiffeners has been much augmented and improved, the increase in the breadths and depths of vessels during late years having produced larger areas of bulkhead plating and greater strains on same. The ends of the stiffeners are now much more efficiently connected than formerly. In a few instances stiffening bars have been omitted and the plates flanged instead (Fig. 18, Plate XXV.), and in other cases the plates have been joggled at seams, so as to afford flush surface for stiffening bars (Fig. 20, Plate XXV.). Another system of stiffening recently introduced consists in double flanging the plates (Fig. 19, Plate XXV.), thus forming very effective stiffeners on each vertical strake of bulkhead plating without using stiffening bars.

Shell Plating.—Although the question of how best to fit the strakes of plating forming the shell was a problem which greatly exercised the early iron shipbuilders, and led to many curious plans being proposed, the "sunk and raised," or, as it is better known, the "in and out" system of shell plating was adopted by practically universal consent, and has been almost exclusively employed. Very little alteration has taken place in the arrangement of the shell plates, but the introduction of steel rendered practicable the production of much larger and wider plates than was possible in the manufacture of iron, and of these some shipbuilding firms have largely availed themselves, and now pride themselves on the exceedingly long shell plates and deck plates used in the construction of their ships, thus entailing fewer butt joints, and consequently making a stronger and lighter structure. Other builders, however, have not thought it worth their while to lay down specially long rolls, planing machines, etc., and provide the heavier tackle necessary for manipulating these unwieldy plates, or risk the labour complications that may be thereby entailed. Moreover, many shipowners are chary about having such large plates fitted in their ships, having in view the fact that the majority of repairing establishments are not equipped with the requisite plant for coping with them.

Regarding the butts of the shell plates, it is rather amusing now to think of the feelings of horror with which most shipbuilders and shipowners received the suggestion to overlap the shell butts, but time has cured all this, sentiment has given place to practical utility and economy, and the overlapped butts have gradually emerged from their original position under the flat of the bottom, and crept strake by strake up the

sides, until nowadays it is by no means uncommon to find the shell butts overlapped throughout, including even poop, bridge, and forecastle sides and stern plating. Experience has demonstrated that the adoption of this form of joint was a step in the right direction, for the overlap butt, whilst being lighter and cheaper than the strapped butt joint, stands better, and does not waste or need recaulking to anything like the extent the edge-and-edge butt did. Overlapped butts are very often associated with scarphed seams, the tapered packing being thus done away with, and a neater, lighter, and more efficient finish is obtained.

Perhaps the boldest and most novel alteration in the custom of fitting the strakes of shell plating, is that which has been so successfully brought into vogue on the Wear during the last two years. The writer refers to what is called the patent "joggled system of plating," shown on Fig. 23 (Plate XXVI.). The idea of forming the seam connections of strakes of plating in this fashion is by no means a new one, but it is due to the courageous originality and inventive skill of an eminent firm of Sunderland shipbuilders that the mechanical difficulties standing in the way of the practical application of this method to shipbuilding work have been effectively overcome by means of the introduction of simple yet ingenious machinery, which has been devised and patented by them for forming the "joggle" on the edges of the plates. As will be seen by reference to Plate XXVII., the machine in question is in general appearance and arrangement somewhat like an ordinary vertical punching or shearing machine. Outside of the plate gap revolve top and bottom rollers, placed at a suitable horizontal distance from one another, these having spherical edges, the plate is joggled without sustaining any injury. Of course it would not be possible to treat ordinary ship quality iron plates in this manner, but with mild steel no such difficulty presents itself.

Although some additional work is entailed in joggling the edges of the plates forming the outside strakes, there is, on the whole, a saving of labour by this system. The punching and fitting of the packing slips being entirely dispensed with, the three-ply riveting at the frames behind the outside strakes is done away with, and shorter rivets are required. The leading structural advantage gained by this system—which, by the way, seems particularly well adapted for oil tank steamers—is the fitting of all the shell strakes directly against the frames, and the consequent abolition of the packing slips or liners behind the outer or raised strakes. These only added weight without contributing in any way to strength, and conduced to bad workmanship.

There is, besides, a saving of packing in the deck and tank top plating when the joggled system is extended to these parts of the ship, and the bulkheads, too, may be constructed on the joggled plan, as a flush surface is then provided for the stiffening bars. In addition to these economies in weight and practical advantages, the writer understands that the patentees further claim credit for the weight of the bulkhead liners which must needs be omitted when joggled shell plates are adopted, but he fails to see upon what grounds the registration societies can sanction the leaving out of these liners without adequate compensation being introduced, because bulkhead liners are not, as is too often supposed, mere packing pieces, but they are important structural members, forming as they do compensating straps over the weakened section of the shell through the double line of closely-spaced rivets in the bulkhead frames, and if they are not fitted then some well-considered arrangement of brackets should, in the writer's opinion, be fitted between the shell plating and the bulkhead, or the bulkhead frame might be kept sufficiently inboard to allow a continuous liner strap being placed behind the weakened section of the shell. No doubt the "joggled shell" affords, on the whole, greater structural strength due to the stiffening of the shell plates by the joggling process, and if the joggled seams are well fitted the shearing strains on the seam rivets will be somewhat reduced.

It is claimed, too, that there is a very appreciable economy in cost of production, the saving on the riveting and packing alone being largely in excess of the cost of the additional labour entailed in joggling the plates.

Regarding the saving in weight due to the adoption of this system, it is calculated that a reduction of from 2 to 3 per cent. is effected, and after allowing for loss of displacement through the absence of the projecting outside strakes, the patentees estimate that on an ordinary 5,000 ton cargo steamer there is a net increase of some 35 tons in the vessel's deadweight capacity, an advantage not to be despised by shipowners in these close-cutting times.

The principal objection against the joggled system, from a shipowner's point of view, is the difficulty of effecting shell repairs until the time comes when joggling machines will be found in most repairing establishments, for hand joggling would be a slow, costly proceeding. All things considered, however, the advantages of the joggled system greatly outweigh the disadvantages, and it is more than probable that it will force its way ahead by virtue of the importance of its merits, and its general adoption should only be a question of time.

Another scheme having for its object the exclusion of shell packing, and the direct attachment of the shell plating to the frames, has been patented by a well-known consulting engineer of Liverpool. The arrangement consists of flanging the seams to a moderate angle, as shown on Fig. 21 (Plate XXV.), and slotting off a portion of the inner plate where it crosses the frames. No practical shipbuilder is likely to attempt the adoption of such a complicated plan, the slotting of the plates would be a tedious, costly, and difficult operation, especially at the ends of the vessel, where it would be almost impossible to carry it out, and the seam riveting at the frames would be extremely unsatisfactory and unworkmanlike; the effective width of the strake would also be reduced by the slots, and every plate in each strake would require to be machined in flanging, instead of alternate strakes only, as in the joggled system.

Yet another device for obtaining a direct attachment of both the raised and sunken strakes of shell plating to the frames is now being promulgated; indeed, the writer understands that in one instance at least it has actually been carried into effect on the Clyde. By the plan in question the frames are joggled so as to form recesses into which the inside or sunken strakes are fitted, somewhat as shown in Fig. 22 (Plate XXV.), the joggling is done on the bars before they are bent. Many and great practical difficulties present themselves in the adoption of this system, but machinery might be devised that would to some extent lessen them, on the face of it, however, this plan does not seem one likely to be generally adopted.

Double Bottoms.—Cellular double bottoms have now almost completely superseded the old girders-on-floor system of construction. The cellular bottoms are usually built either with solid deep floors on every frame, and one or more intercostal plates fitted between them according to the beam of the ship (Fig. 25, Plate XXVIII.), or with solid floor plates fitted on alternate frames with two or three intercostal girders worked between (Fig. 26, Plate XXVIII.), the intermediate frames consisting of deep angle irons kneed to the centre keelson and tank margin plates, stiffening angles being fitted under the tank top plating, or the plating thickened in lieu of same. Opinions are somewhat divided as to the relative merits and demerits of these two systems of cellular construction. It is claimed for the former that there is better distribution of strength, less riveting, smaller areas of unsupported bottom plating, and that both the tank top and shell plating are efficiently stiffened. On the other hand, the advocates of the latter system claim

that it is somewhat simpler and less costly to construct, and at the same time more accessible and roomy for riveting, repairs, cementing, etc.

One of the greatest troubles, indeed the crying evil in modern steamers, more particularly in those built of steel, is the startlingly rapid corrosion of the tank top plating, floors, and intercostal plates under the boilers. In many instances these parts have been found entirely eaten through in even four years, thus entailing very expensive and difficult repairs. In fact so serious has this trouble become that many shipowners will not have a ballast tank fitted under the boilers, but have the No. 2 tank arranged to extend some three or four frame spaces into the stokehold, and the No. 3 tank to extend under the engines only, thus leaving a large well under the boilers (Fig. 27, Plate XXVIII.). It is, however, a very serious matter to lose the advantages of the inner bottom in such a vitally important part of the ship, because in the event of the outer bottom being holed in wake of this open space, the vessel's safety would be imperilled; hence some owners prefer to retain the inner bottom under the boilers, taking special measures to prevent as far as possible severe corrosion setting in. Lloyd's rules now require all the parts in question to be thickened, and in many ships iron is used for them to the exclusion of steel. Different kinds of enamels and cements have also been tried with varying success, and galvanizing has also been resorted to. A favourite practice has been on first signs of excessive corrosion of tank top appearing, to cover the surface with Portland cement, and this, the writer considers, is a grave mistake, as the cement rarely adheres thoroughly to the plating, and water is apt to search in below the cement, causing the corrosion to go on quicker than ever. Sometimes the boilers have been raised to 15 or 18 inches above the tank top; proposals, too, have occasionally been made (though the writer has not heard of their having been adopted) to either extend the non-conducting substance further round the boiler bottom, or suspend baffle plates under the uncovered bottom of the boiler so as to prevent the heat striking the tank top. In some steamers built under the writer's supervision the sounding and air pipes to the boiler room tank have been increased to 5 or 6 inches in diameter, and ventilators fitted into the pipes at the deck for the purpose of causing a current of air to pass through the tank: so far this plan has been found very effectual. A special arrangement of air pipes for ventilating these tanks by means of induced draught has been patented by a Newcastle engineer, it has been fitted to several vessels, and is said to have given satisfactory results.

Pillars.—Departures have occasionally been made from the orthodox solid round iron beam pillar in favour of hollow tubular pillars, or pillars formed of double T or channel irons, fitted back to back (Fig. 28, Plate XXIX.).

Solid round iron pillars are no doubt a cheap, but somewhat unsatisfactory arrangement, being heavy, clumsy, unscientific, and too frequently manufactured of very inferior material; but the theoretically superior tubular pillars are costly, and liable to become indented when sharp pieces of cargo come in contact with them, whilst the T and channel forms, though admirable from a scientific point of view, are objectionable in practice, on account of the liability of the sharp edges of their flanges either to be damaged by, or cause damage to, cargo. Channel bars of heavy section have, however, the advantage of forming very effective ties as well as struts, and their heads and feet can be more efficiently attached to the deck and tank than can other sections. Pillars forming hold ladders at ends of hatches have been formed of hollow half-round moulding (Fig. 29, Plate XXIX.). These can be punched instead of drilled to take the rungs. They are found to answer the purpose fairly well.

Rails and Mouldings.—For several years past there has been manifested a steadily growing tendency to dispense with all those unnecessary mouldings—so dear especially to the hearts of Scotch shipbuilders—which popularly constituted one of the supposed superiorities of Clyde-built ships over those constructed in this district. In this severely practical age considerations of utility and economy take precedence over questions of appearance, hence, in some extreme cases, cargo vessels have been built almost entirely denuded of mouldings, not having even a knuckle moulding, thus giving the vessel a bare, eyebrowless, sort of appearance. The ponderous wood bulwark rails have given place to lighter and neater sections in iron, such as Fig. 33 (Plate XXIX.). The solid half-round moulding in time, has made way for hollow half-round or thin convex bars, and the exigencies of cheap production have occasionally abolished even these for a plain flat bar, fitted as in Fig. 35 (Plate XXIX.).

Flanging.—This is now practised to a very large and still growing extent in shipbuilding work. Mild steel lends itself readily to this treatment. Weight is lessened, and the cost of production reduced, but as a general rule, a structure composed of plates connected together by angle bars is stronger, and has greater rigidity and stability than when flanged connections are adopted, especially when steel is the material employed. It is not, therefore, surprising that the registration societies

have not encouraged flanging, but it has been successfully applied to many structural details such as stringer connections to shell, bracket knees to stringers, etc.

Important improvements effected in the machines employed in shipbuilding, and the introduction of new machinery, have also played prominent parts in connection with the principal modifications made in structural details. Among the new plant that has been added to the equipment of most shipyards may be mentioned bevelling machines, cold saws, slotting machines for scarphed joints, manhole punches, plate levelling rolls, hydraulic riveters, and flanging machines, etc., whilst very useful improvements have been made in punching and shearing machines, drilling and countersinking machines, rolls, planing machines, and garboard strake benders.

What the nature of the chief departures that are likely to be made in the future will be is a somewhat risky forecast to make, but from present indications it would seem that they will most probably be found in the increased application of labour-saving and more efficient machines, rather than new arrangements of material, though further advances in the processes of steel and iron making may possibly enable the manufacturers to produce the more complicated sections of bars, etc., at prices which will admit of them being yet more extensively used.

It is also impossible to foresee to what extent the introduction of electrical plant may affect shipbuilding practice; indeed, there are not wanting signs that we are on the eve of very important developments in this respect, some shipbuilding firms having already commenced to install electrical plant; and it may, perhaps, be that the adoption of building sheds, such as have been erected in America, and at least in one large shipyard on the Tyne, may have a marked influence in the shipbuilding methods of the near future.

Many modifications have been made in the smaller details of ship construction, but the writer considers that those he has dealt with constitute the principal departures from old-established practice.

The paper, he fears, has assumed a somewhat olla-podrida character, but he would beg the indulgence of the members on the score of the desirability of pausing occasionally in the march of progress to call the roll and survey the innovations and alterations effected in structural details, and to consider the expediency or otherwise of the steps taken. In conclusion, the writer ventures to hope that the paper, embracing as it does such a large area, may bring about an exhaustive and useful discussion on the points involved.

DISCUSSION.

Mr. G. E. MACARTHY said he would like to express his gratification to the writer of the paper for his very able exposition of a question that really affected the shipowners very much. It was an excellent paper, too, in this respect, that it was made quite understandable to all. Those of them who might be untechnical or unscientific might come there meeting after meeting and listen to very technical or scientific details which they could not understand. That was not the case here, and he had followed it very carefully, and it was all so explicit that there seemed little further to explain. In regard to what was said about the rudder and the new arrangement, did he understand Mr. James to mean that it was a perfect plate?

Mr. JAMES—It is made of one plate.

Mr. MACARTHY—In your sketch there is a connection at the top?

Mr. JAMES—Yes; I have not drawn the stock of the rudder, just the outline.

Mr. MACARTHY—You will take that off altogether?

Mr. JAMES—Yes.

Mr. MACARTHY said he fully endorsed the writer's remarks with respect to the new patent style of plating—the "joggled" system. The idea was good; it seemed the proper thing, and ought to have been seen to long ago. There was no doubt that overlapping plates made a far stronger job than the old-fashioned style. He really thought that the writer of this paper deserved great credit for making the question so clear and distinct, and he thanked him very much.

Mr. A. CRUICKSHANK said there was really only one point that he took exception to in Mr. James's paper, that was where Mr. James, referring to the flanging, said that weight was lessened. Taking floor plates in double bottoms as an instance, with Lloyd's putting on $\frac{1}{20}$ inch in thickness where these plates are flanged, there is really a slight loss in weight when the top edge only is flanged, as is generally the case. When this is done only half an angle bar is saved, and $\frac{1}{20}$ inch on the floors is, as a rule, of greater weight. When both top and bottom of the floors are flanged a

slight saving is effected, but other considerations generally prevent this being done, such as in a moderately fine ship, where the bottom edge would have to be flanged in a curved line, and it would be exceedingly laborious and expensive to make a good job. There were other parts probably where a saving would be effected by flanging in such work as stringers, but if Lloyd's put it on there the same as in the floor plates this would depend on the width of the stringers. With regard to the joggled shell plating, he did not know whether Lloyd's had asked for anything extra in the thickness; perhaps they might have asked the same as in the flanged floors. However, Mr. Doxford might answer that question, as it was one of the points to be considered in getting at the actual weight of shell when plated on this system. He thanked Mr. James for his very pleasant paper, calling up, as it did, reminiscences of old times.

Mr. J. Stewart said he thought the paper very useful, and one that gave room for a good deal of discussion. There was only one point that he would deal with, and that was the ballast tank under the boilers, and the very serious corrosion that took place there—a fact which many shipowners knew to their cost. As Mr. James had said, the trouble from this cause had become so serious that in many cases no ballast tank had been fitted under the boilers, leaving a large open well at this part, and he referred to the element of danger in this plan in the event of the vessel getting pierced at such a vital part. One simple way of getting over this difficulty was to make this part not an open well, but a dry tank—a plan which had been adopted in one or two instances to his knowledge, and probably it was not uncommon. A feature of the paper was the consideration given to the common interests of shipbuilder and shipowner, and it was gratifying to note the increased attention given to the details of design with a view to facilitate repairs afterwards—a very important matter to shipowners and underwriters.

Mr. Hugh Macoll, in responding to the call of the Past-President, said he would have preferred to have had a little more time to look over the paper, although it was very clear and well written, and the subjects in themselves were easily understood. One of the great difficulties in introducing anything new, apart from the difficulty noticed in the paper, was the labour question. The main outlet for new ideas was clearly redistribution of scantlings and greater use of sectional material, which in the initiatory stages cost more money to get and handle, because the people were new to it, and then in direct proportion as they did away with, say, riveting, the riveters thought they should get the same amount out of

the job, and they rebelled unless they got the same money for a greatly reduced number of rivets. In this way it was not easy to make headway in shipbuilding. Arguments were of little use. A simple illustration was bilge keels. Very commonly there was the double bar and bulb, with three tiers of rivets. On one occasion they were compelled to make an alteration in the usual arrangement by using a single bar, and there was a disturbance, because these gentlemen lost one tier of rivets, and they wanted to get the same amount of money out of the job. So there was not much inducement left to introduce new ideas. In regard to "registries" they were just what their name indicated—they were registries—they did not initiate, they generally fought as long as they could against anything new or that they considered they might lose credit by; when it was no longer a question of the success of the new idea they adopted it, and then assured people, who did not know any better, that it had been introduced and encouraged by them. Yet all practical improvements had been introduced in direct opposition to them. Another difficulty in getting out new styles was the variety of sizes of material which they had to contemplate in the ship. If they had one size of ship, one material, and one style of bar, it would be an easy business; but take the framing of a small ship, when they run it out at the ends, and diminished the section gradually or scientifically there was only a very few tons of one section, and might have to wait months for these few tons of material being rolled off. He (Mr. Macoll) mentioned a case where they were told they might have to wait three months before they could get the bars unless willing to pay more than the bars should cost altogether as extra for cutting and shipping rolls. As to the flat plate keel, he had seen lately a vessel with flat keel and pretty flat bottom very severely strained by going into the graving dock. A flat keel might be a very good thing, but like every other good thing in this world, they might get too much of it in other respects. In this case the upper blades were hard wood and hooped at the ends. No caps were used, and the blocks by use had worn hollow several inches in the centre, and so missed taking the weight of the ship on the keel plate, which at the centre line was well supported by the centre keelson, and the weight of the vessel was taken by the garboard strake, with the result that a considerable portion of the bottom was set up. The possibility of this mischance was got over very nicely in the large White Star boats. They put on a slab about 4½ inches thick and 2½ feet wide, which made a fine bearing for the keel blocks. About the stems, the modern arrangement of putting in the slab all the way through in connection with flat keel was very handy, but when they found in renewal or replacing,

as was sometimes the case, a considerable number of tap bolts connecting the end of the fore plate getting their heads polished off when the vessel had been going through mud or something, there was not much saving in feeling for those rivets, together with the difficulty of getting out the rivets attaching the stem foot to the centre keelson, and when it all came to be fixed up there was not much difference in the repairing part of the business. It was a curious thing, although it was well known, that large forgings had a large amount of contraction in them, the immense amount of cold water, not to mention red ink, with which they were treated, made it like sacrilege—at all events a few years ago—to propose a malleable forging, scarphed in two or more pieces, but why scarphing was taken as a matter of course with a steel casting, and could not be tolerated in an iron forging, it was difficult to say. As regarded the single plate rudders, even in these slack rivets had been known to occur with the ordinary forged rudder having plating on both sides; he had found if the back or bow was made of sufficient thickness and also wide enough to take double riveting and the rivets properly put in there would be no difficulty from slack rivets. Another arrangement of flanging lower stringer plates, not mentioned in the paper, was sometimes used. Referring to Fig. 15 (Plate XXIV.) in the paper:—

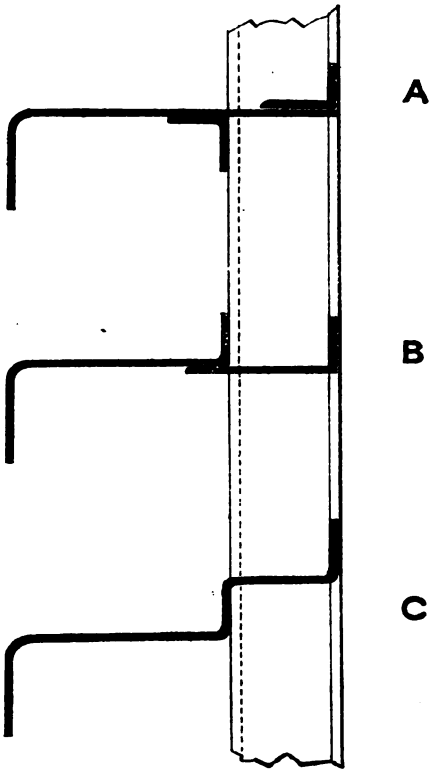
(A) Instead of using the inner angle, make the plate thicker and flange it down on the inner edge. (See sketch on opposite page.)

(B) In addition, flange it up against the reverse bar.

(C) In addition, flange it against the shell plating.

Further than this flanging could scarcely go in this case. For vessels built for carrying coal it was a capital arrangement. The coals came "sliding" down very nicely without much bother. The double lugs on the bulb frames were much better if single. They could not well cut the bulb off the frame, and to pack it up did not ensure sound riveting. With bulb frames it was better to have a much larger lug piece on the plain side of the frame to take four rivets, and have the fore and aft flange large enough to take four rivets in the kelson, then a good sound piece of work was obtained. In the big Atlantic steamers great use was made of the channel beams as well as frames, and they lent themselves to the purpose, easily crept, and not much labour on them. They seemed to do very well. As to cutting the stringer plate of the reverse frame, and fitting a wide angle to take the shell rivets, mentioned as one of Mr. Bell's improvements in modern shipbuilding, this was really one of his good ideas. As to the cellular bottom, it was a moot question which was the best. If they were going to have their vessel damaged frequently

it would be better to have ordinary floors. Besides, to have to go crawling along those cellular bottoms with $\frac{3}{8}$ inch plates and supported every 4 feet was about as uncomfortable and inconvenient a job as they could find for poor humanity. The reverse bar to lie on and get along was considerably less uncomfortable. It was a point often overlooked, but it was one worth consideration all the same. The difficulty with the joggled shell plate was one clearly of machinery and would find its level by and by. The matter would be developed, and as people got more inclined to spend money in machinery more would be used, and they would see more "joggled" ships being built. Then as to the ventilation and the tanks, he (Mr. Macoll) would go a little further about the boiler. He would go 2 feet. Every inch they raised the boiler from the tank top they improved the position of affairs. He had known $\frac{3}{8}$ inch tank tops lasting for thirteen years. He thought that good enough. On the other hand, he had known $\frac{7}{16}$ inch steel floor plate give out in about four years under the tank top, and in one case the floors round the upper edge of lightning holes were gone to a knife edge. He could never get a very satisfactory explanation of this. The ventilation of the boiler room tanks was a comparatively new arrangement, but sufficient time had not elapsed to decide by it in all cases: he gathered that what was proposed was to put in separate pipes. Was he right in understanding that the separate pipes were for ventilation?



Mr. JAMES—They are just enlarged air pipes, up to 5 or 6 inches, and used as sounding pipes.

Mr. MACOLL, in continuation, said recently in repairing some vessels he had fitted elbows under deck to existing air pipes and brought them up on deck into cowls in convenient positions, and the arrangement seemed to answer fairly well, but there had not been sufficient length of time to form any idea of the result. He did not at all agree with the remark in the paper that hold pillars or rather ladders of hollow half-round iron answered its purpose. He most decidedly objected to that. In four years he found they looked seedy and damaged, and in eight years they looked still more so, and when they came to their third survey they were not safe enough for a monkey to get up, far less a man. For cheapness it was good enough, but not for a lasting job. One point he had not mentioned was the flanging of the floors, not only flanging them to the tank top but to the shell, which was a method that obtained in more than one place at least; and one thing was, it made a very good bottom. They had a straight line from the tank to the keel, and a very nice floor with a good rise at the ends. There was a tendency to cut the bilge rather square. Then if they flanged the end of the floor against the centre keelson and the outer end flanged against the tank margin he did not think flanging in this case could go much further. In conclusion, he thought the paper covered a good deal of ground and required looking over and considering. All alterations were not improvements; but certainly they felt they were getting on little by little; and ships had to be built of less material and as little labour as possible. The result was, on the whole, an improvement. He had only made a sort of running commentary on the paper, and desired to thank Mr. James for bringing so many recent notions before them in so interesting a manner.

The discussion was adjourned, and the meeting dissolved.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

TWELFTH SESSION, 1895-96.

PROCEEDINGS.

SIXTH GENERAL MEETING OF THE SESSION, HELD IN THE LECTURE HALL OF THE SUBSCRIPTION LITERARY SOCIETY, SUNDERLAND, ON FRIDAY EVENING, MARCH 20TH, 1896.

ROBERT THOMPSON, ESQ., J.P., PAST-PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last General Meeting, held in Newcastle, on February 14th, 1896, which were approved by the members present, and signed by the Past-President.

The ballot for new members having been taken, the Past-President appointed Messrs. H. Macoll and R. H. Muir to examine the voting papers, and the following gentlemen were declared elected :—

MEMBERS.

Bailey, Charles H., Engineer and Ship Repairer, Tyne Engine Works, Newport.

Crookston, John, Consulting Engineer, 72, Mark Lane, London, S.E.

Cumming, William, Superintendent Engineer, c/o James Laing, Esq., Deptford Shipyard, Sunderland.

Evans, William T., Superintendent Engineer, c/o Messrs. John Cory & Sons, Mount Stuart Square, Cardiff.

Good, Farrant, Engineer, c/o Messrs. Bute Dry Dock Co., Ltd., Roath Basin, Cardiff.

Jackson, Albert S., Superintendent Engineer, c/o Messrs. The Baron Hambro' Steamship Co., Ltd., Mount Stuart Square, Cardiff.

Jones, Charles, Superintendent Engineer, 10, Glyurhondda Street, Cardiff.

Landreth, Cowen, Superintendent Engineer, 34, Simonside Terrace, Newcastle-on-Tyne.

Seddon, Joseph A., Ship Surveyor, The British Corporation Registry of Shipping, 56, Mount Stuart Square, Cardiff.

Sibun, William, Engineer Surveyor, Lloyd's Registry of Shipping, Bute Docks, Cardiff.

ASSOCIATE.

Hodge, W. P., Marine Superintendent, c/o Messrs. John Cory & Sons, Mount Stuart Square, Cardiff.

GRADUATES.

Dixon, William John, Engineering Student, 10, Granville Road, Newcastle-on-Tyne.

Kent, Samuel N., Apprentice Engineer, Lindenhurst, Heaton, Newcastle-on-Tyne.

Mr. J. R. FOTHERGILL (West Hartlepool) said the absence of the President (Ald. Richardson, M.P.) was due to his being occupied with duties in connection with the government of the country.

INVITATION TO CARDIFF.

The PAST-PRESIDENT drew attention to the following letter which had been received from Mr. J. F. Walliker inviting the Institution to visit Cardiff :—

BUTE DOCKS, CARDIFF,
February 19th, 1896.

The Secretary, North-East Coast
Institution of Engineers and Shipbuilders.

DEAR SIR,—A meeting of gentlemen connected with the engineering and shipping industries of this district was held in this town last evening, presided over by Mr. John Lowdon, J.P., of Barry, when it was unanimously decided that a hearty invitation should be sent to the members of the Institution asking them to visit Cardiff and the Bristol Channel Ports during the ensuing summer.

The date and duration of the visit was left open for future arrangement, but it was considered that this should be so settled as not to interfere with the summer meetings of other kindred societies. July was mentioned as a suitable time, and a hope was expressed that the visit would extend to at least three days, as this or even a longer period could be made interesting and useful to the members.

I shall be glad of a reply as soon as convenient, and also an idea of the probable number that would take advantage of the invitation.

Yours faithfully,
On behalf of the Committee,
JOHN F. WALLIKER,
Hon. Secretary pro tem.

He had no doubt they would all have received the circular from the Secretary asking the members who intended going to intimate their acceptance of the invitation. He was quite sure from the way the proposal had been taken up by an influential committee in Cardiff that it would be well worthy of a large acceptance on the part of the members of this Institution. An exhibition was to be held in Cardiff at the time,

and the committee of shipbuilders and engineers had collected a considerable sum with a view to their entertainment and instruction. Besides visiting places of interest they would have joint meetings, at which papers would be read, and the occasion made useful and pleasurable. He hoped they would let the Secretary have their replies as soon as possible.

The discussion on Mr. M. C. James's paper "On some Structural Details of Modern Ships" was resumed.

Mr. R. M. FERRIER read a paper on "The Determination of the Forces which Produce Vibrations with Three-crank Engines at High Speeds."

Mr. A. E. DOXFORD read a paper on "On Balancing High Speed Engines."

ADJOURNED DISCUSSION ON MR. M. C. JAMES'S PAPER "ON SOME STRUCTURAL DETAILS OF MODERN SHIPS."

The SECRETARY (Mr. Duckitt) said, before resuming the discussion on Mr. James's paper, he had to say that he had a letter from Mr. C. D. Doxford regretting that he could not attend that meeting. There was a question asked, he said, whether Lloyd's approved of the system of joggled plating? They (Messrs. Doxford) were in a position to answer in the affirmative.

Mr. R. H. MUIR said he thought this paper of Mr. James's must be very refreshing to shipbuilders, because it brought before them, in a very concise manner, the improvements in structural details which had crept into shipbuilding in the last ten years or so. They, as shipbuilders, forgot that these were recent innovations, because after they had repeated a thing once or twice it passed out of their minds as being anything more than up-to-date. Several of the details which Mr. James had drawn attention to were not treated from the shipbuilders' point of view, but from the shipowners', and occasionally from the commercial and repairers' standpoint. Now, to treat of all these, made it a very difficult problem. Generally speaking, he should imagine, that shipbuilders did not very much care what happened when the ship required repairs; their first object being to make a thoroughly good structure. In building a ship, they did not make much provision for her going on rocks and tearing her bottom out. Mr. James's remarks in the first part of the paper as to the clogging and hindering effects of the registration societies must be modified, when he (Mr. James) later on would clog and hinder the builders. For instance, when dealing with long shell plates and the joggling of shell plates, he thought they had gone rather fast, because no repairing dockyards had yet introduced the joggling machines. Mr. James said the plain flat keel plate had almost universally been adopted. That might be, but was there not at present signs of reviving the bar keels? Within the last month or so several builders had been enquiring at other firms if they could drill some keel bars and bend the garboard strakes for them. He had been told of one firm that had not built a bar keel ship for ten years. His own (Mr. Muir's) experience for the last few years, had been about an equal number of each; at present he had three bar keels on the stocks alongside one another. He was glad Mr. James admitted the absence of the bar keel was prejudicial to steering, and he might have added, to

rolling, unless bilge fins were fitted. The system of attaching the parallel stem bar to the plate keel by means of angle irons or flanged plates he could not consider other than a makeshift job. He did not like it; it was not to be compared with the forging made to the shape of the forefoot. Mr. James suggested (Fig. 5, Plate XXIV.) that the deep girder system of framing the reverse bar should be reversed, that is, it should be put into the bosom of the frame. The objection to that was, the plate knee and beam would require to be fitted on the back of the reverse frame, making it very difficult to get the shell rivets in. Mr. James also referred to the use of the Z bar as being copied from war vessels. He thought these were now pretty common, and the workmen were becoming very expert at turning those bars. Z bars he (Mr. Muir) thought were rather better than the channel bars. He did not mean as far as strength was concerned, but for this reason, they could rivet the shell much easier. Channel bars and Z bars had been used frequently as beams, also H section instead of built beams. Of course special machinery was required for working these sections. Reference was made (Fig. 18, Plate XXV.) to the system of flanging bulkhead plates. Flanging both edges of one plate thus, was equally good, and saved the handling of half the number of plates. He thought the bulkhead liners should be fitted diamond shape, or they might be oblong, and only project 3 inches past the edges of the bars, sufficient to take one row of rivets. This would allow of caulking all round. He would increase the thickness of the bulkhead bars by 25 per cent., and increase the spacing of rivets. The same arrangement would apply elsewhere, for instance, the bridge front bulkheads, there the deck plating was riddled with holes to suit the water-tight spacing for thin bars, in fact the deck was postage-stamped right across. Thicker bars and wider spacing of holes seemed to him a reasonable way of preserving the strength. What was said in the paper regarding rails and mouldings being "so dear especially to the hearts of Scotch shipbuilders, which popularly constituted one of the supposed superiorities of Clyde built ships," he could only take as a bit of sarcasm. The Scotch shipbuilders no doubt liked mouldings and wooden rails on high class passenger vessels, and the same could be said for the shipbuilders on this coast when they built similar vessels. The Scotch shipbuilders, no more than the North-East Coast builders, did very much for the love of it, each fulfilled his contract, and so it was the shipowner who said what he wanted, and got what he paid for. In cargo vessels pure and simple there may be no need for such extras, but even there they found owners specifying for

cutwater bows, figure head, trail boards, name boards, stern carving, etc. This the Past-President could corroborate, he having two ships with all these "things of beauty" building at this moment.

Mr. E. W. De Rusett said he would venture a few remarks upon the deep girder framing, shown on Plate XXIV. He might say his firm had built a good many vessels with this type of framing, and had had no difficulty whatever with regard to the keelson lugs, referred to in Fig. 3 (Plate XXIV.), at all events not in any good-sized ship, carrying, say, 4,000 to 5,000 tons deadweight. The arrangement shown in Fig. 4 (Plate XXIV.), would add unnecessarily to the cost. Framing, illustrated by Fig. 5 (Plate XXIV.), had also been adopted by his firm, but there were various difficulties connected with it, more particularly with regard to the punching of the frame and reverse frame, as these had to be turned over to punch, which gave some additional labour to the men. With regard to the beam knee (Fig. 5, Plate XXIV.), he might say that they had had no difficulty on this account. The beam knee was simply carried to the depth of the reverse bar only, and not to the bosom of the frame. This was approved by Lloyd's, and made a good job. The attachment of ceiling to frames (Fig. 8, Plate XXIV.) made a very good job—a first-rate job—it was cheap, and answered well. With regard to the remarks made by Mr. Muir as to the parallel stem bar, his firm did not connect it at the foot to the shell and keelson by lugs, but by an intercostal keelson riveted to the side of stem, and thence to the shell. This made a secure attachment, and he did not think they would go back to the old system, neither on the score of cost nor labour. There were a great many other valuable points in the paper, and he thought he would not take up their time by referring to any more of them, as, no doubt, they had been ably referred to by previous speakers.

The Secretary read the following communication from Mr. Andrew Young, of Bureau Veritas Register of Shipping:—

Dear Mr. Duckitt,

One might infer from Mr. James's paper that it has been the special function of classification societies to exercise by reason of their published rules a "clogging and hindering effect" upon shipbuilding generally, and that they have been guilty of "fostering mere unthinking repetition, stifling originality of thought, deadening the inventive faculties, stultifying and retarding progressive efforts." All this, too, has

been done in cold blood, or rather with the aid of "cold red ink" kept for the very purpose of ejecting upon and poisoning the product of ingenious brains.

This is indeed a formidable indictment, almost enough to make a modest society blush, if not fade away altogether. Being upon the staff of one of those societies, I naturally desire to repudiate, as far as it is concerned, the charge of throttling innovations or standing in the way of any new developments. Of course it is not my place at present to review the work of the Bureau Veritas in this connection, but I think there must be many associated with this Institution who would be amongst the first to testify to our appreciation of any improvement suggested by shipbuilders or others. I venture to mention only two instances which must be well known to all. I think it will not be seriously disputed that it was under the fostering care of Veritas that the building of petroleum and turret steamers has been encouraged, and initial confidence in them established. I certainly believe that with these facts in mind the author would not wilfully include Veritas in the "many quarters" he refers to.

It might be well to take this opportunity of clearly stating the purpose for which such a society exists. Its business, of course, is not shipbuilding, shipowning, chartering, or insuring, but is closely allied with all these. Its primary function is to assign a public character to a vessel, based upon a knowledge of her construction and technical qualities, and to publish an accurate and complete record or register of vessels entrusted to the survey of the society, which gives to all interested parties a trustworthy account of the principal features and condition of these vessels.

From the nature of such work, its policy must be somewhat conservative; its characteristic virtue must be caution in order to safeguard not only its own reputation but also the interests of shipowners, who are naturally jealous of the reputation of their property. So that great caution must be exercised before sanctioning departure from well-tried methods. Shipbuilding, like society, should have its brakes.

As regards the other parts of the paper, I have not much to say. The pros and cons of each part are well stated. I may add that in side-stringers, channel bars are sometimes used, though there is a difficulty in their manipulation.

I have pleasure in thanking Mr. James for his paper, which is a very useful one.

Yours faithfully,

ANDREW YOUNG.

The PAST-PRESIDENT said they were all instructed by a paper like that of Mr. James's, and there was the variety obtained by discussion. He was sorry Mr. Charles Doxford could not be with them that night, for he had been making a great many innovations lately, the latest being a balanced single plate rudder. He (the Past-President) had asked him to bring a photograph of it, but regretted he could not be with them. With respect to the Z frames, he might say his firm had used nothing else for some years, and so far as their furnacemen were concerned, they had no difficulty to get them to work, and altogether they considered it a very efficient frame. It had this advantage over the joggled plating which saved the packing and so reduced the length of the rivets; in the Z bars they saved the rivets altogether. The reverse frame and the bar being combined no riveting was required. That was a great saving, it could be punched so easily, and cut so clean, and was very strong. With respect to weight saved by joggled-plating, he thought it would be a pity for the statement to go into the *Transactions* without some positive information proving the saving. He (Mr. James) gave them a ship of 5,000 tons with a saving by joggled-plating of 35 tons. They (the Past-President's firm) had finished a ship of 5,250 tons deadweight, the total packing in her being 33 tons. To compare her with the joggled ship there would be an allowance of 13 tons, owing to a loss of displacement on account of the joggles making a net increase of deadweight of 20 tons in favour of the joggled ship. Now his firm had got a scarphing machine he had no doubt they could reduce the packing by several tons, and thus reduce the gain of deadweight owing to the joggle system. He thought savings of this kind were best verified because the practice might differ in various places. For instance, in tank tops they had not used packing for years. By joggling the top of the tank web plating and by arranging the deck plating in in and out strakes, instead of out and in, they reduced the packing to a small taper. He checked these weights very carefully: what was actually ordered, put into the ship, and left. The ships had proved very satisfactory, and it was a cheaper job than the ordinary way of plating, and quite as strong as far as the structural strength of the ship went.

The discussion was again adjourned.

THE DETERMINATION OF THE FORCES WHICH PRODUCE VIBRATIONS WITH THREE-CRANK ENGINES AT HIGH SPEEDS.

By R. M. FERRIER, B.Sc.

[Read before the Institution, in Sunderland, on March 20th, 1896.]

The increasing use of high speed engines for marine purposes, and the occurrence in many vessels of violent vibrations which have been shown to be due to the action of the engines, have caused much attention to be directed to the subject.

The paper is an attempt to analyse the forces which are produced in the action of a triple expansion engine, with three cranks, and to determine the magnitude of these forces with sufficient exactitude for practical purposes.

A particular engine has been taken and the forces worked out for it in detail, because the writer's object has been to illustrate the method of determining the forces actually involved rather than to draw general deductions from theoretical reasoning. Messrs. Doxford have very kindly given him full details of one of their engines, and this forms the subject of the paper. The methods, however, are perfectly general, and may be applied to any engine.

The forces to be considered may be divided into two sets. 1st. The vertical forces arising from the action of the reciprocating parts.

These consist of the piston and the parts attached to it which move up and down with varying speed. They must be brought to rest at the end of each stroke and set in motion again at the beginning of the following stroke.

This action is the same whether the engine is driven by external means or by steam pressure. In the former case, if the piston be supposed at the top of the stroke it must be set in motion by a pull in the piston rod and connecting rod, which will tend to lift the engine. This pull diminishes as the piston moves downwards, and in the second half of the stroke changes into an upward push, which brings the piston to rest at the end of the stroke. During the second half of the stroke therefore, the tendency is to push the engine downwards.

With steam pressure in the cylinder, the whole pressure on the piston will not be transmitted through the connecting rod, etc., to the bed-plate, but will be lessened by the force needed to set the reciprocating parts in motion. The upward pressure on the cylinder cover will therefore be greater than the downward force on the bed-plate by that amount, and so the resultant effect will be an excess of upward force exactly equal to the force needed to set the reciprocating parts in motion. This will be the case at any speed, so that it is unnecessary to consider the steam pressure as producing any unbalanced forces causing vibration.

The amount of the force at different angles of the revolution is found by the formula—

$$\text{Force} = \frac{WV^2}{gR}\left(\cos A + \frac{\cos 2A}{n}\right);$$

where W = weight of reciprocating parts,
V = speed of crank-pin in feet per second,
g = acceleration of gravity = 32,
R = radius of crank in feet,
A = angle of crank measured from top centre,
n = ratio of connecting rod to crank.

Another form of the formula which is often useful is—

$$\text{Force} = \cdot 00034\ WN^2R\left(\cos A + \frac{\cos 2A}{n}\right); \quad (1)$$

where N = number of revolutions per minute.

A table of the quantity in brackets, calculated for every 30 degrees is placed in the Appendix (Table I.).

The second set of forces which cause vibration is due to the centrifugal forces caused by the rotating parts.

These forces may each be calculated by the usual formula—

$$\text{Centrifugal force} = \frac{WV^2}{gR};$$

$$\text{or by—centrifugal force} = \cdot 00034\ WN^2R; \quad (2)$$

where W = weight of rotating part,
V = speed of its centre of gravity in feet per second,
g = acceleration of gravity,
R = radius of centre of gravity in feet,
N = number of revolutions per minute.

These forces always act radially, but for the purpose of combining them with the vertical forces, they have been resolved at every 30 degrees into vertical and horizontal components, and the sum of the vertical forces due to both reciprocating and rotating parts taken as the total disturbing force in the vertical direction.

The horizontal components of the centrifugal forces on the rotating parts are the only forces causing horizontal vibrations.

The oblique action of the connecting rod causes equal horizontal forces at its ends, but these are in opposite directions, and so will balance one another. Their moment is equal to the turning moment on the shaft.

The variation of the turning moment on the shaft forms also a possible cause of vibration. As the torsion of the shaft causes the propeller to turn in the water, the resistance of the water will cause the vessel to heel slightly in the opposite direction to that in which the shaft turns.

As the turning moment varies this will cause a change of the amount of heeling, and so set up torsional vibrations.

The diagram of turning moment (or crank effort) has therefore been drawn (Fig. 16, Plate XXXV.) by the usual method from the diagrams of effective pressure on the piston, account being taken of the inertia of the reciprocating parts.

The following are details of the engines :—

$$\text{Cylinders, } \frac{15 \text{ ins.} - 22\tfrac{1}{2} \text{ ins.} - 33\tfrac{1}{2} \text{ ins.}}{18 \text{ ins.}}.$$

$$\text{Connecting rod, 3 feet} - 4\tfrac{1}{2} \text{ ins.} \therefore \frac{\text{conn. rod}}{\text{crank}} = 4\tfrac{1}{2} = n.$$

H.P. and I.P. valves, 5 inches travel ; L.P. valve, $5\frac{1}{2}$ inches travel ; eccentric rods, 3 feet long. Air pump was driven by levers worked by crank and connecting rod on the forward end of the shaft. Crank, 4 inches ; connecting rod, 2 feet.

With respect to the connecting rod the usual approximation has been made, *i.e.*, that one-half is taken as reciprocating, and the other half as rotating with the crank pin.

WEIGHTS.

	H.P. Lbs.	I.P. Lbs.	L.P. Lbs.
Reciprocating parts—			
Piston, piston rod, and half connecting rod ...	276	323	420
Slide valve and rod, and half eccentric rod ...	215	312	431
Half astern eccentric rod and strap	32	32	32
Rotating parts—			
Crank pins and half connecting rods	139	139	139
Crank webs (centre of gravity at $6\frac{3}{4}$ inches radius)	77	83	91
Eccentrics, with half eccentric rod and strap ...	32	32	32
Balance weights	566	—	704

Air pump, rod, crosshead, etc., 123 lbs.

Fig. 1 (Plate XXX.) shows the arrangement of weights on shaft. Fig. 2 gives the end view of shaft, showing the angular position of

eccentrics with respect to the cranks, which are at 120 degs., as usual. The crank driving the air pump is at the same angle as the low pressure crank.

The balance weights are attached to the high pressure and low pressure cranks only. They have been calculated by the method given by Mr. Yarrow, and which will be described by Mr. A. E. Doxford in a paper to be read at this meeting. The weights given are with the centres of gravity at 6 inches radius.

All the forces have been calculated for a speed of 354 revolutions per minute, at which the indicator diagrams were taken, from which the effective pressure curves (Fig. 15, Plate XXXV.) have been drawn.

The diagrams of forces are drawn to a scale of half an inch to a ton; those of moments to a scale of $\frac{1}{8}$ inch to a foot-ton.

DIAGRAMS.—The vertical forces acting throughout a complete revolution of the H.P. crank are shown in Fig. 3 (Plate XXX.). The forces due to the reciprocating parts were calculated from formula (1) for every 30 degs. The figures for the H.P. reciprocating parts are given in the Appendix. These values plotted to scale gave the dotted line. Next, the centrifugal forces due to the rotating parts were calculated from formula (2). The total centrifugal force was found to be 2·8 tons. Drawing a circle (Fig. 4) with K M = 2·8 as radius, and taking at every 30 degs. the vertical component as L M, these are added to the forces given by the reciprocating parts, and the full line A shows the vertical force produced during the revolution of the high pressure crank.

The same method has been followed for the I.P. and L.P. cranks, the six eccentrics, the air pump, and balance weights.

In combining them, as in Fig. 5 (Plate XXXI.), care must be taken to place the curves so that each line cuts them so as to give all the forces when the H.P. crank is at the given angle. The easiest method is to draw each curve separately on tracing paper and slide it horizontally until it is in the proper position.

Taking the difference between the sum of the upward and downward forces at each angle of 30 degs., we get the curve of resultant vertical force shown by the full line in Fig. 6 (Plate XXXI.), neglecting the effect of the balance weights.

This shows that though the forces acting are large, that due to the low pressure piston being 10·25 tons at its maximum, they so nearly balance one another that the resultant force never exceeds 1·3 tons.

The dotted line shows the effect of the balance weights on the vertical forces. The maximum force is reduced to ·98 ton.

The horizontal forces are shown in Fig. 7 (Plate XXXII.). They are due to the rotating parts only, and are, in fact, the horizontal components of the centrifugal forces, as K L in Fig. 4 (Plate XXX.). These are also measured for every 30 degs., and are shown in Fig. 7 (Plate XXXII.) for the three cranks and the balance weights. The horizontal forces due to the eccentrics were so small that they have been drawn to an enlarged scale in Fig. 8 (Plate XXXII.), and only their resultant, which never exceeds ·06 ton, is drawn in Fig. 7 (Plate XXXII.).

The resultant horizontal force acting on the engine is shown in Fig. 9 (Plate XXXII.). The full line shows the resultant without balance weights, the maximum being ·2 ton. The dotted line shows the effect of the balance weights, which increase the forces to a maximum of 1·1 tons.

The amount of the rocking moments produced by these forces has been shown to be often of more importance than the magnitude of the forces themselves. In estimating the rocking moments the difficulty is to decide about what centre they should be taken.

Here they have been taken about the centre of gravity of the engine, which has been *assumed* to coincide with the centre of the I.P. crank.

Each vertical force will then produce a rocking moment tending to tilt the engines in a fore-and-aft direction. The amount of the moment will depend on the distance from the centre of gravity as well as on the magnitude of the force. An upward force forward of the centre of gravity will produce a similar tilting effect to that of a downward force acting aft of the centre of gravity.

Fig. 10 (Plate XXXIII.) shows the values of the rocking moments produced by the vertical forces. The resultant moment is shown in Fig. 11 (Plate XXXIII.), the full line showing the resultant moment, neglecting the balance weights. The maximum value is 43·5 foot-tons.

The dotted line shows the effect of the balance weights, the maximum moment being reduced to 7·5 foot-tons.

The horizontal moments also taken about the centre of gravity are shown in Fig. 12 (Plate XXXIV.). Here, again, the moments due to the eccentrics have been drawn separately to a larger scale (10 times) in Fig. 13 (Plate XXXIV.), and only their resultant is drawn in Fig. 12.

The resultant moment of all the horizontal forces (without balance weights) is shown by the full line in Fig. 14 (Plate XXXIV.), the maximum moment being 13·5 foot-tons.

The effect of the balance weights is shown by the dotted line, which gives a maximum moment of 24 foot-tons.

The effect of the rotating balance weights is therefore to increase the horizontal moments as well as to reverse their direction, as is shown by the curves.

The variation of the turning moment on the shaft is shown in Fig. 16 (Plate XXXV.), which has been drawn from the effective pressure curves shown in Fig. 15 (Plate XXXV.), allowance being made for the inertia of the reciprocating parts, as shown.

The turning moment of each crank is also shown as well as their combined moment.

The diagram shows that the turning moment varies from a maximum of 10 foot-tons to a minimum of 4·6 foot-tons, the mean being 8 foot-tons.

APPENDIX I.—Table I.

If $n = 4\frac{1}{2}$ as in the present case.

Angle A.		Cos A + $\frac{\cos 2A}{n}$.		Cos A + $\frac{\cos 2A}{4\frac{1}{2}}$.
0°	...	$1 + \frac{1}{n}$	...	1·222
30°	...	$\cdot866 + \frac{\cdot5}{n}$	...	·977
60°	...	$\cdot5 - \frac{\cdot5}{n}$	...	·388
90°	...	$0 - \frac{1}{n}$	..	− ·222
120°	...	$-\cdot5 - \frac{\cdot5}{n}$	...	− ·611
150°	...	$-\cdot866 + \frac{\cdot5}{n}$	...	− ·755
180°	...	$-1 + \frac{1}{n}$	...	− ·777
210°	...	$-\cdot866 + \frac{\cdot5}{n}$	...	− ·755
240°	...	$-\cdot5 - \frac{\cdot5}{n}$	...	− ·611
270°	...	$0 - \frac{1}{n}$	...	− ·222
300°	...	$\cdot5 - \frac{\cdot5}{n}$	...	·388
330°	...	$\cdot866 + \frac{\cdot5}{n}$	...	·977
360°	...	$1 + \frac{1}{n}$	...	1·222

It will be seen from the above that the values are the same on the return half of the revolution, so that only the downstroke need be calculated.

APPENDIX II.

If W = 276 lbs. = ·123 ton for H.P. piston, etc.

N = 354 revolutions per minute.

R = 9 inches = ·75 foot.

Then ·00034 WN^2R = 3·93 tons. Multiplying by the numbers in column 3 of the preceding table, we get the following forces produced by the reciprocating parts on H.P. when the crank is at the given angles from top centre :—

Angle A.	Force in Tons.
0°	4·804
30°	3·840
60°	1·525
90°	− ·873
120°	− 2·401
150°	− 2·967
180°	− 3·057
210°	− 2·967
240°	− 2·401
270°	− ·873
300°	1·525
330°	3·840
360°	4·804

ON BALANCING HIGH SPEED ENGINES.

By A. E. DOXFORD, B.A. Cantab.

[Read before the Institution, in Sunderland, on March 20th, 1896.]

The object of this paper is to describe briefly the forces in high speed marine engines which tend to produce vibrations in ships, and to give a method of finding graphically the weights that may be applied to approximately balance these forces.

The forces to be balanced are those due to the reciprocating and rotary parts of the engine, and the latter can be balanced absolutely by a rotary weight; the former, however, can only be partially so balanced, owing to the angularity of the connecting rod, and, further, a rotary balance weight sets up horizontal forces equal to the vertical ones which it has neutralised.

Thus it is seen that, if rotary balance weights are employed, they should be as small as possible, apart from the consideration of adding weight to the vessel.

The vertical forces necessary to give motion to the reciprocating parts are transmitted entirely to the bed-plate, as in the case of an infinite connecting rod, the effect of the finite connecting rod being to introduce horizontal forces in the main bearings equal to the thrusts on the guides.

This may be easily seen from Fig. 1 (Plate XXXVI.).

Let P be the force necessary to give motion to the reciprocating parts. Then, if this motion be given through the connecting rod, the pull in the connecting rod is P sec θ, and the pressure on the guide is P tan θ.

The action of the crank shaft on the main bearings will therefore be a force P sec θ parallel to the connecting rod, and in the same sense as the pull of the connecting rod on the crank pin.

Resolving P sec θ we get P vertically and P tan θ horizontally.

Thus, what the connecting rod does is to introduce a couple, P tan θ, OA = P tan θ, OM cosec θ = P sec θ OM, and this is equal to the turning moment on the crank shaft due to the reciprocating parts, but in the opposite sense. In other words, the connecting rod enables a turning moment to be applied to the crank shaft, and therefore necessarily sets up a reacting couple in the main structure of the engine.

The same reasoning holds good with regard to steam pressures, and the reacting couples due to the reciprocating parts merely modify those due to steam pressures. Theoretically, these couples will give a slight varying list to the vessel and set up small torsional strains, but will not produce vibrations.*

The next consideration is: To what extent does a rotary weight balance a reciprocating weight?

Let a reciprocating weight of mass m be driven by a crank of radius r and connecting rod of length l. Place a rotary weight of mass m directly opposite to the crank and at radius r.

Then, at the dead centres, there is an unbalanced upward vertical force acting on the bed-plate of $m\omega^2 r \frac{r}{l}$, and when the crank is horizontal there is an unbalanced downward vertical force acting on the bed-plate of $m\omega^2 r \frac{r}{\sqrt{l^2 - r^2}}$ (ω being the angular velocity of the crank).

The greatest reciprocating weight in the engines about to be considered is 608 lbs. The connecting rod is 3 feet—4 inch centres. The crank is 9 inch radius. Therefore, if a rotary weight of 608 lbs. were placed opposite the crank at 9 inch radius, there would be, at 400 revolutions, a resultant upward force acting on the bed-plate of 5,581 lbs. at the dead centres, and a resultant downward force of 5,739 lbs. when the crank is horizontal.

These forces appear very large, but, when all the reciprocating parts of an engine are taken into account, it is seen that they balance one another to a certain extent. The remaining question is: How great can these unbalanced forces due to the angularity of the connecting rod be without prejudicially affecting the vessel by producing vibrations?

In H.M. torpedo destroyers, "Haughty" and "Hardy," both the rotary and reciprocating parts are approximately balanced by one another, and by rotary weights, and up to 400 revolutions there is no vertical vibration in the vessel, and only a very slight horizontal vibration at the extreme ends. Thus it is known from experience that, with the weights and their relative positions shown in Figs. 2 and 3 (Plates XXXVII. and XXXVIII.) and the particular position in the vessel in which these engines are placed, the otherwise unbalanced forces due to the reciprocating weights can be dealt with by rotary weights, and the horizontal forces set up by the rotary balance weights and the unbalanced portion of the vertical forces, due to the angularity of the connecting rod, can be neglected.

* It is not intended to assert that these couples do not *tend* to set up vibrations, but that, in the writer's opinion, they will not produce vibrations of any moment.

In these vessels the engines are approximately balanced by rotary weights placed on the end cranks. The forward balance weight is 75·83 lbs. at 9 inch radius and the after one is 177 lbs. at 9 inch radius, making a total of 252·83 lbs. Had rotary weights on each crank been employed there would have been a total of 3,172 lbs. at 9 inch radius, if such balance weights could have been applied, and the effect of the valve gears would not have been taken into account. Further, this enormous weight would have been setting up horizontal forces to such an extent that there is very little doubt that considerable vibrations would have been experienced.

Figs. 2, 3, and 4 (Plates XXXVII., XXXVIII., and XXXIX.) show a geometrical method of finding the rotary weights placed at the two end cranks which will balance the rotary and reciprocating parts to the extent stated above. In Fig. 2, A, B, C, etc., are the positions along the shaft of the cranks and eccentrics. All reciprocating weights are considered as rotary weights at radii equal to the cranks or eccentrics driving them. From A, B, C, etc., are set up A A′, B B′, C C′, etc., equal to the respective weights multiplied by their radii, and they, therefore, represent the centripetal forces acting on these weights when revolving at unit angular velocity.

From the upper extremities of these forces are drawn lines parallel to the base line, meeting the vertical at A in B″, E″, F″, etc. (B′ and B″ are not shown in the diagram). Lines are then drawn joining B″, E″, etc., to D, and these lines divide the respective forces in the ratio of the distances of the forces from A and D.

For example, G G′ is divided at O, so that $\frac{G'O}{OG} = \frac{AG}{GD}$. Therefore the force G G′ can be replaced by two parallel forces O G and O G′ in the same plane at A and D respectively.

In this way all the forces are replaced by forces at A and D inversely proportional to their distances from these points. For convenience, the forces near D are divided by lines drawn from A instead of D. For instance, C C′ is divided by A C″ in O so that $\frac{C'O}{OC} = \frac{DC}{CA}$, and therefore C C′ is replaced by O C′ at A and O C at D. When the force is divided externally at O, as is L L′, the portion O L is positive, and O L′ negative.

Fig. 3 shows the forces at A in Fig. 2 at their correct positions round the shaft (O B extends beyond the diagram, but its magnitude is shown by *nb*). From A is drawn A*l*′ parallel to O L′, *l*′*h* parallel to O H, and so on to *c*′*g* parallel to O G. Then by the polygon of forces, O*g* represents

in magnitude and direction the resultant of all the forces O A, O L′, O H, etc., and a force equal and opposite to O*g* will balance all these forces.

Similarly, in Fig. 4, O*e*′ represents in magnitude and direction the resultant of the forces O D, O J′, O B′, etc. (O C is not shown, but is equal to *lc*). In Figs. 2, 3, and 4, 1 inch = 10 units of force. O*g* in Fig. 3 measures 5 feet 8¼ inches, and therefore represents 682·5 units of force. To find the rotary weight which will, at unit angular velocity, require this centripetal force 682·5 must be divided by the distance of the weight from the centre of the shaft. Therefore the forward balance weight is 75·83 lbs. at 9 inches from the centre of the shaft, and makes an angle of $\tan^{-1}$ ·64 with the high pressure crank produced.

In the same way the after-balance weight is found to be 177 lbs. at 9 inch radius, making an angle of $\tan^{-1}$ 2·69 with the second low pressure crank produced.

To show the accuracy with which this method can be worked, the forward balance weight was found by the ordinary method of calculating the centre of gravity described by Mr. Yarrow to be 75·668 lbs., making an angle of $\tan^{-1}$ ·64, working to three places of decimals.

The advantages of dealing with this subject geometrically are—that one is much less liable to make a mistake; one can see at a glance how by slight variations in the design of the engine the necessary balance weights can be reduced; and the time occupied is extremely short.

For instance, looking at Fig. 3, it is seen that by increasing O B the resultant O*g* will be reduced, and, from Fig. 4, by diminishing O B′ the resultant O*e*′ will be reduced, and, from Fig. 2, O B will be increased, and O B′ reduced by bringing B nearer to A. Similarly, both the resultants are reduced by bringing C nearer to D, showing that the engine is more nearly self-balanced with each pair of cylinders as close together as possible than had the valve gears separated them. Messrs. Thorneycroft even go so far as to incline the cylinders from the vertical, so as to bring them still closer.

It is also seen that by increasing the weight of the air pump (N N′, Fig. 2) and the stern-way valve gear for the second low pressure cylinder (M M′, Fig. 2) that both balance weights will be reduced. Further, any alterations made as above do not necessitate the diagrams being reconstructed, but their exact effect can be found by a few strokes of the pen.

In Fig. 3 the air pump (O N) comes directly opposite to the resultant of the forces. It was, of course, placed in this particular position so as to assist in balancing the engine.

It has been pointed out above that a rotary weight is far from balancing a reciprocating weight. The same may be said of a reciprocating counterweight under the same conditions, but to twice the extent; that is to say, on the dead centres there is a resultant upward vertical force acting on the bed-plate of $2m\omega^2 r \frac{r}{l}$, and when the crank is horizontal a resultant downward force of $2m\omega^2 r \frac{r}{\sqrt{l^2 - r^2}}$.

Thus, bobweights may be employed as has been done by Mr. Yarrow, or the end reciprocating weights may be so arranged as to act as bobweights as explained by Mr. Schlick, but still there will be certain unbalanced vertical forces, and although it has not yet been found necessary to take these forces into consideration, they should not be lost sight of as each step in advance is being taken.

The PAST-PRESIDENT said he must congratulate the Institution upon the production of two such papers, the one by Mr. Ferrier and the other by Mr. Doxford. He was very proud to think that they had a Bachelor of Science on the one hand, and B.A. of Cambridge on the other, reading kindred papers on the same evening, and the results of their training and learning, given there that night, was very satisfactory to the Institution.

The proceedings were adjourned.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

TWELFTH SESSION, 1895-96.

PROCEEDINGS.

SEVENTH GENERAL MEETING OF THE SESSION, HELD IN THE ATHENÆUM, WEST HARTLEPOOL, ON SATURDAY EVENING, APRIL 25TH, 1896.

ROBERT THOMPSON, ESQ., J.P., PAST-PRESIDENT, IN THE CHAIR.

THE SECRETARY read the minutes of the last General Meeting held in Sunderland, on March 20th, 1896, which were approved by the members present, and signed by the Past-President.

The ballot for new members having been taken, the Past-President appointed Messrs. W. Stevenson and M. C. James to examine the voting papers, and the following gentlemen were declared elected :—

MEMBERS.

Common, John B. A., Engineer, 51, Mount Stuart Square, Docks, Cardiff.
Hesketh, Thomas, Marine Surveyor, Bryn Tirion, Richmond Road, Cardiff.
McKechnie, James, Marine Engineer, Messrs. Naval Construction and Armaments Co., Barrow-in-Furness.
Nicholson, Walter E., Boilermaker, Hebburn Boiler Works, Hebburn-on-Tyne.
Whitfield, Thomas, Engineer, Messrs. Tyne Dock Engineering Co., South Shields.

GRADUATE TO MEMBER.

Duckitt, John Brentnall, Electrical Engineer, Messrs. Sunderland Forge Co., St. Luke's Road, Sunderland.

ASSOCIATES.

Hogg, John Thomas, Shipping Ironmonger, Bute Docks, Cardiff.
Storey, Christopher, Agent, 28, Holly Avenue, Jesmond, Newcastle-on-Tyne.
Robson, John William, Timber Merchant, G, King Street, Newcastle-on-Tyne.

GRADUATE.

Turner, Charles N., Apprentice Engineer, 2, Newburn Lane, Newburn-on-Tyne.

The PAST-PRESIDENT intimated that he had a telegram from their President to say that on account of business in London it was impossible for him to be present.

NOMINATIONS FOR THE COUNCIL.

The PAST-PRESIDENT said that in accordance with Article X. of the Constitution the following gentlemen would retire from the Council :—President—Ald. Thos. Richardson, B.A., M.P. ; Vice-Presidents—Messrs. A. Laing, James Patterson, and M. Sandison ; Ordinary Members of Council—Messrs E. W. De Rusett, C. D. Doxford, H. Fownes, W. Hök, and J. C. Stirzaker ; Hon. Treasurer—Mr. G. E. Macarthy.

On behalf of the Council, in accordance with Bye-law 11, he had to nominate the following gentlemen, to be balloted for, to fill up the vacancies :—President—Col. Henry F. Swan ; Vice-Presidents (three to be elected)—Messrs. E. W. De Rusett, James Patterson, M. Sandison, and J. C. Stirzaker ; Ordinary Members of Council (five to be elected)—Messrs. Robert P. Doxford, M. C. James, Robert H. Muir, W. G. Spence, Robert Wallis, and R. S. White ; Hon. Treasurer—Mr. G. E. Macarthy.

The PAST-PRESIDENT intimated that it was now open to any member at that meeting to make additional nominations.

Mr. G. D. WEIR nominated Mr. Summers Hunter as an Ordinary Member of Council.

Mr. W. STEVENSON nominated Mr. Henry Fownes for the Vice-Presidency.

There being no further nominations the Past-President declared the list closed.

THE VISIT TO CARDIFF.

Mr. J. R. FOTHERGILL, by request of the Past-President, reported the result of a visit to Cardiff along with the Secretary (Mr. Duckitt) in connection with the invitation to the Institution from the engineers and shipbuilders of that district. It was proposed to proceed from Newcastle by special train on Monday, 22nd June, and return by special train from Cardiff on the following Saturday. Each day would be taken up with visits and entertainments, for which a local committee had arranged, and the particulars of which would be circulated in a programme of the proceedings.

The discussion on Mr. M. C. James's paper "On Some Structural Details of Modern Ships" was resumed and adjourned.

The discussion on Mr. R. M. Ferrier's and Mr. A. E. Doxford's papers on "High Speed Engines" was resumed and adjourned.

ADJOURNED DISCUSSION ON MR. M. C. JAMES'S PAPER "ON SOME STRUCTURAL DETAILS OF MODERN SHIPS."

Mr. GEORGE N. ARNISON, in resuming the discussion, said it was full of details, and must have required considerable time for its preparation. Any remarks made on such a paper were apt to be disjointed. He had not much to say from a critical point of view, the paper being generally very complete. As regards the joggling of plating—one of the most important improvements in ship construction—it might be interesting to remember that joggling was used in the shell of a vessel far earlier than in any instance referred to by Mr. James, viz., in a barque called the "Richard Cobden," built in the year 1844 by Mr. James Hodgson, of Liverpool, classed twenty years in black in the late Liverpool Underwriters' Registry, the class being renewed in the year 1865. He remembered seeing a midship section of the vessel after she was twenty years of age, which showed that joggling was adopted in order to dispense with the shell packing—the same object that had been accomplished by Messrs. William Doxford & Sons by their patent machine. In the "Richard Cobden," instead of joggling the shell plating, the frames were joggled, the plates being fitted clinker fashion, each strake having an in and out edge. It was a very expensive process, and did not appear to have been repeated. This instance, however, served to show that very early in iron shipbuilding the question of obviating the use of packing engaged the attention of shipbuilders. Another point he would call attention to was as regards the hold stringers. Mr. James illustrated what might be called the new ways of fitting them in Figs. 15 and 16 (Plate XXIV.), and what they might call the old fashion in Figs. 13 and 14 (Plate XXIV.). The arrangements shown in Figs. 15 and 16 got over a difficulty which very often must present itself to those who were dealing with details in ships. Take a ship carrying a coal cargo outwards and a grain cargo homewards, there were awkward pockets in Figs. 13 and 14 inside the reverse bars, and he remembered a ship being built not so long ago where the builders were requested to put chocks in between the frames to facilitate the removal of the dirt that accumulated. This the builders declined to do, unless the extra cost was allowed. He would like to know Mr. James's experience in this matter. Certainly, if the plans shown in Figs. 15 and 16 were adopted, the pockets would be very easily cleaned, but when hold stringers

were fitted, as in Figs. 13 and 14, there was of necessity an accumulation of filth in these corners which would be apt to damage a clean cargo if not removed. So the arrangement in Figs. 15 and 16 was a decided improvement, and if shipbuilders would not adopt it the owners should compel them to put chocks in the spaces between the frames, as otherwise the ship could not be said to be efficient for the purpose of carrying any kind of cargo.

Mr. J. R. FOTHERGILL said there were many gentlemen present who had considerable experience in the repairs of damaged stern frames. It was well known when a ship took the ground the stern post usually fared badly, and this they might well anticipate, seeing a steamer's draught was usually greatest aft. When a steamer dry-docked after grounding and damage was found to the stern frame, it usually meant a serious repair account, as there was no reliable means at present for repairing such frames in their places. His experience was that it was cheaper to at once cut the frames out and not attempt welding in places in the dock. This frequently meant considerable time and floating the ship out of dock until the frame was repaired, whereas, with frames shown in Mr. James's paper, a new piece could be fitted, or the damaged piece disconnected and straightened, without disturbing the frame in place, and thus it appeared to him, from a shipowner's point of view, such jointed frames were not without advantage. With regard to joggled plates, he did not think that anyone was going to claim that joggling plates was a new idea, but he thought that every practical man would admit that it made a better job than at present, where they depended so much upon packing. The question was what was the objection to the practice? The answer—cost. He understood that had been overcome by the special machinery referred to by the author in his paper. If that was so the sooner it became universal the better.

The discussion was further adjourned.

DISCUSSION ON MR. R. M. FERRIER'S AND MR. A. E. DOXFORD'S PAPERS ON "HIGH SPEED ENGINES."

Mr. JAMES PATTERSON said that the papers were so clearly written, and everything so carefully described, that one could not fail to be struck with the ability displayed in them, in fact the papers did not lend themselves to that fertile source of discussion—adverse criticism. The subject of balanced engines was one with which he had had a great deal to do lately on the Yarrow, Schlick and Tweedy system. Mr. Ferrier's and Mr. Doxford's methods of analysis very closely resembled those they had adopted, and they had found the graphic method of the polygon of forces most useful. Mr. Ferrier alluded to a point which he did not at first sight apprehend, namely, the necessity of taking the rocking moments round the centre of gravity of the engine. This, however, comes to exactly the same thing as the convention they adopted, namely, to find the unbalanced forces tending to lift or depress the engine bodily, which must take place through the centre of gravity, and the remaining couples which tend to rock the engine, and the moment of a couple is, of course, independent of location. The design of engine illustrated by Mr. Doxford was undoubtedly a good one, because the vertical balance of the main forces could, and had been, obtained with a comparatively small addition of balance-weights. Mr. Doxford had, however, been careful to point out that it was only the main forces that had been considered, that is, the forces due to the angularity of the connecting rods had been neglected. He further pointed out that the balance of the main vertical forces had been obtained by an increase in the want of balance horizontally. He (Mr. Patterson) was, unfortunately, unable to criticise the balance in detail, as it would be necessary to have the moving weights separated into their revolving and reciprocating components, which was not done in the paper. He had, however, carefully gone into the question, taking the weights of a four-crank balanced triple-expansion engine Messrs. Wigham Richardson & Co. are now building, and he found that if it had been of the same design as Messrs. Doxford's engine they would have had—

1. To make a longer engine and therefore to make it structurally heavier.
2. To add 2½ tons to the moving weights.
3. To increase the shafting throughout to allow for the unequal turning moment obtained with the two low-pressure cylinders opposite to one another, and at right angles to the H.P. and I.P.

4. The vertical balance not so good.
5. The torsional balance not so good.
6. The horizontal balance very much worse.
7. The cranks not interchangeable even in pairs.

He might say that the engines referred to were 45 inches stroke, and add that, however, a balance may be obtained by the addition of balance-weights to small engines he thought that it would be found impracticable in larger sizes. In conclusion he must say he had been much interested in the papers, and obliged to the gentlemen who wrote them.

The discussion was adjourned and the meeting dissolved.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

TWELFTH SESSION, 1895-96.

PROCEEDINGS.

CLOSING BUSINESS MEETING OF THE SESSION, HELD IN THE LECTURE HALL OF THE LITERARY AND PHILOSOPHICAL SOCIETY, NEWCASTLE-UPON-TYNE, ON TUESDAY EVENING, MAY 19TH, 1896.

ALDERMAN THOS. RICHARDSON, B.A., M.P., PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the previous General Meeting, held in West Hartlepool, on 25th April, 1896, which were approved by the members present, and signed by the President.

The ballot for new members having been taken, the President appointed Messrs. H. Macoll and R. L. Weighton to examine the voting papers, and the following gentlemen were declared elected :—

MEMBERS.

Barrett, A., Engineering Science Teacher, Staith House, West Hartlepool.
Brew, George, Marine Surveyor and Consulting Engineer, 85, Water Street, Boston, U.S. America.
Littledale, John W. E., Engineer, 65, Campbell Street, Newcastle-upon-Tyne.
See, Horace, Consulting Engineer, etc., 1, Broadway, New York City, U.S.A.
Walliker, John George, Engineer, Barry, near Cardiff.

ASSOCIATES.

Bird, William, Secretary of American and Moor Edge Steam Laundries, Newcastle-upon-Tyne, 8, Latimer Street, Tynemouth.
Riddle, John C., Accountant, 60, Grey Street, Newcastle-upon-Tyne.

CONSULTATIVE COMMITTEE TO THE BOARD OF TRADE.

The appointment of the following gentlemen by the several Institutions, as a Consultative Committee to the Marine Department of the Board of Trade, was intimated :—

Appointed by the Institution of Naval Architects, London.—Dr. F. Elgar (E), F.R.S., London ; Mr. A. Blechynden (E), Greenwich ; Mr. A. Adamson (S), Barrow-in-Furness ; Mr. A. E. Seaton (S), Hull.

Appointed by the North-East Coast Institution of Engineers and Shipbuilders.—Col. H. F. Swan (S), Newcastle-upon-Tyne ; Col. John Price (S), Newcastle-upon-Tyne ; Mr. D. B. Morison (E), Hartlepool ; Mr. J. H. Irwin (E), Sunderland.

Appointed by the Institution of Engineers and Shipbuilders in Scotland.—Mr. Jas. Hamilton (S), Glasgow ; Mr. C. Connell (S), Whiteinch, Glasgow ; Mr. James Denny (E), Dumbarton ; Mr. W. Morison (E), Glasgow.

Appointed by the Chamber of Commerce, Belfast.—Mr. Pratten (Messrs. Harland & Wolff, Limited).

The PRESIDENT, in explaining the appointment, said most of them would be aware there had been for some time a desire on the part of engineers and shipbuilders generally throughout the country, that an endeavour should be made to have a committee to act with the Board of Trade, as the consultative committee now acted at Lloyd's, and which had proved very successful. The executive of the scientific institutions and employers' associations connected with engineering and shipbuilding on the Tyne, the Wear, the Tees, Hartlepool, the Clyde, and Belfast, were called together in London, and appointed Mr. Wolff, M.P., Col. Denny, M.P., and himself, to have an interview with Mr. Ritchie, M.P., President of the Board of Trade, who agreed to receive a deputation on the subject. When they met they put before Mr. Ritchie certain proposals, which proposals, he said, he was not able to accept, although he was quite in sympathy with their movement. He pointed out the Board of Trade was not in the same position in regard to this matter as Lloyd's Committee. The difficulty they had to face was, that they had to deal with a large number of different matters, and he did not see how he could make an exception in their case ; but he said whilst he could not accept the committee on the lines they proposed he would only be too happy to consult from time to time any committee they might appoint. It seemed the general desire that the committee should be formed on the

same lines as that elected as the consultative committee for Lloyd's, so that in following that line, of course, the Institutions who elected that committee above-mentioned were each desired to appoint four, two shipbuilders and two engineers. As far as Ireland was concerned they had not any scientific institution, so they obtained the thirteenth nomination through the Belfast Chamber of Commerce, and he thought the representative appointed (Mr. Pratten) would be considered, in all their opinions, a most excellent one. He was of opinion this committee might in the future become of great value to the engineers and shipbuilders of the country, and that the Board of Trade would find the value of having such men as had been chosen to consult on technical matters in connection with these great industries. It might in course of time become also a vehicle of communication with the Marine Department regarding the grievances of engineers and shipbuilders in their respective professions.

Mr. M. C. JAMES replied to the discussion on his paper "On Some Structural Details of Modern Ships."

Mr. R. M. FERRIER and Mr. A. E. DOXFORD replied to the discussion on their papers on "High Speed Engines."

The closing business of the session was then proceeded with.

REPLY TO THE DISCUSSION ON MR. M. C. JAMES'S PAPER "ON SOME STRUCTURAL DETAILS OF MODERN SHIPS."

Mr. M. C. JAMES, replying to the discussion on his paper, said it was gratifying to know that the principal object for which this paper was prepared had, to a large extent, been attained, for the reading had been followed by a most instructive and interesting discussion on many of the matters dealt with. There had not, however, arisen very much demanding any further attention at his hands, for, on the whole, the comments of the various speakers had been in pretty close accord with the views advanced in the paper; but some questions had been asked and points raised that called for reply, and with these he now proposed to deal.

Mr. Cruickshank found himself unable to agree with the general statement made that when flanging was adopted weight was lessened, and quoted the very extreme example of a floor plate with the top edge flanged in lieu of a reverse bar. In such a case, owing to the $\frac{1}{20}$th addition to the thickness, wisely, he thought, demanded by Lloyd's, there was certainly no saving in weight, nor was there in any case where the area of the plate was large compared with the lengths of the edges flanged, but flanged floor plates were rarely fitted, and in smaller work, like brackets, knees, etc., there was an absolute and considerable saving in weight. Regarding his enquiry as to whether Lloyd's had asked for any increase to the thickness when joggled plating was adopted, no such addition had, he understood, been demanded, and, indeed, there did not seem to be any valid reason why the joggled plates should be thickened, for it is a vastly different form of joint to a flanged connection, and the joggling process did not produce local molecular disturbance in the material to anything like the extent that flanging did, besides the joggling is always done cold; there is, therefore, no loss by furnacing.

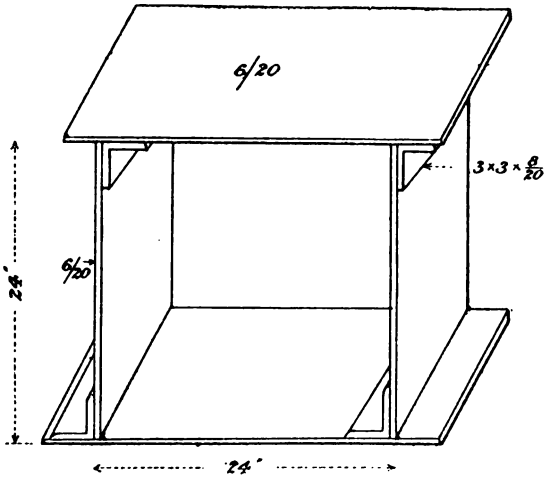
Mr. Stewart spoke with evident feeling on the subject of the grievous corrosion in boiler room ballast tanks, and advocated the plan, sometimes adopted, of maintaining the cellular construction throughout the engine and boiler space, the portion immediately under the boilers being reserved as a dry tank. This was, no doubt, preferable to having a water ballast

compartment at that part, and had not the grave disadvantages of an open bilge; but it was to be feared that the corrosion of the top plating would still go on, though probably at a less rapid rate.

Mr. McColl in his valuable contribution to the discussion very properly emphasized the importance of that ever-to-be-reckoned-with factor in shipbuilding operations, the labour difficulty. It was beyond question that many very desirable structural improvements had been delayed, and in some instances entirely shut out, through considerations of this character; similar impediments were experienced in almost all manufacturing trades; but even the most powerful trade unions—like other autocratic bodies—had eventually to make way for the inexorable march of progress. Mr. McColl also drew attention to the importance of reducing as far as possible, for economy and simplicity's sake, the variety of sections of bars, etc., used in shipbuilding. The buffer or rubber keels described by him were undoubtedly a useful innovation, and similar keels of somewhat less scantling, about 10 inches by 3 inches, are being fitted in several vessels now building in this district. As to the scarphing of forged iron sternposts, he had not experienced the opposition to which Mr. McColl referred, though he had fitted sternposts of this description in about a dozen new vessels during the last three years. The introduction of double riveting in the bow of forged iron framed rudders is a somewhat old idea, which was found to work out fairly well in practice. The extremely ingenious design of flanged stringer sketched by Mr. McColl was a striking illustration of what could be accomplished when the details of construction were not slavishly copied from or made to comply with hard-and-fast books of rules; and a stringer of such a section, though rather diffcult and expensive to construct, would be very suitable in coal and grain carrying vessels. As to the cellular *versus* the girders-on-floor style of double bottom, certainly from a surveyor's, repairer's, or tank crawler's point of view the latter form was the best, but from considerations of structural strength, whether for withstanding longitudinal strains, or in case of grounding, or even economical construction, there could scarcely be two opinions as to which was the superior. Mr. McColl was a little severe on the hollow half-round bars for sides of hold ladders. A somewhat extensive experience of ladders so constructed did not lead him to acquiesce in Mr. McColl's sweeping condemnation of them, though, perhaps, for rough deadweight trades they were not so strong as were solid pillars. It was somewhat surprising to find Mr. McColl describing the flanging of the floors on both top and bottom edges, instead of fitting reverse bars and frames, as making "a nice job," for so far as his somewhat

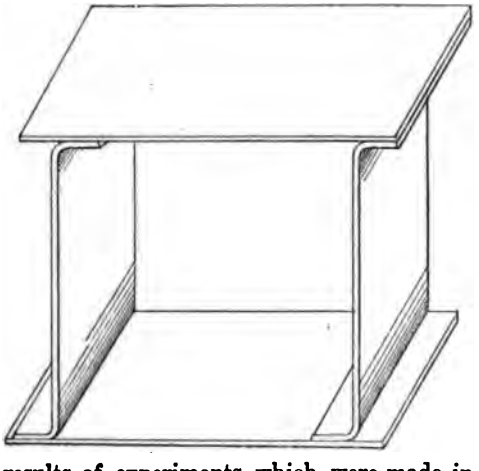
limited experience of this system had gone he had found it lead to most irregular and uneven work, and produce a very nasty job, both for the outer and inner bottoms, owing to the difficulty in setting the flanges of all the floors to exactly the same angle, and maintaining a uniform and

A



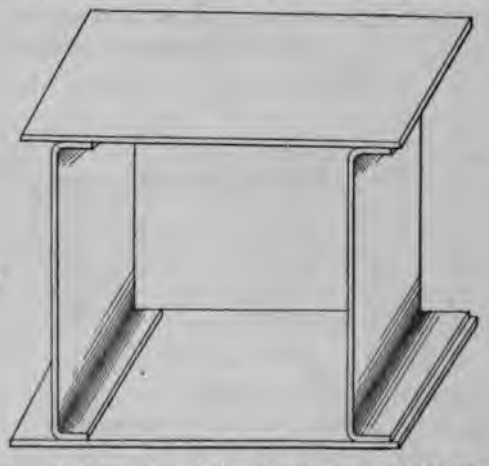
correct depth and height of floors. It was likely similar objections would apply to flanging the floor ends against the tank margin plate. As bearing on the relative efficiencies of combinations of plates and angles compared with flanged joints it might be interesting to put before the

B



Institution the results of experiments which were made in this locality some time ago. Three boxes were built as per sketch. They were all 12 inches long, and of same scantling, and were subjected to crushing forces until they collapsed.

A collapsed under a strain of 48 tons.
B " " " 23 "
C " " " 18 "



Mr. Muir accused him of wishing to clog and hinder the builders because he had advocated structural arrangements which facilitated repairs, and he advanced the somewhat novel and rather mischievous proposition that shipbuilders should not care what happened to a ship when she required repairs, and that they ought not to make much provision for going on rocks and damaging the bottom. To his mind, one of the first guiding principles in the arrangement of the structural details of ships was to make them efficient, as far as ever possible, against the perils of the sea and dangers of navigation to which ships must necessarily be exposed, and all parts should be easily repairable when damaged. Shipbuilders do not exist for themselves alone, and it should be remembered that a ship's life was only beginning when she left her builder's yard. Now, he ventured to think that the shipbuilding firms whose reputations would grow, and whose customers would return to them, would be those who had this fact always in view and rightly appreciated its vital importance. Mr. Muir did not admire the parallel stem bar, with an angle iron attachment to the keel plates; it certainly was not so sightly as the solid bar forged to the shape of the forefoot; but, with care in laying off and construction, it made—as Mr. De Rusett pointed out—a very efficient and trustworthy connection.

Mr. Andrew Young, in his communication, rather unfairly quoted certain extracts from the paper as constituting an accusation against the registration societies that they had deliberately set themselves to retard

progress in the details of ship construction ; but a reference to the context would show that what he sought to maintain was that the very existence of set rules and tables of scantling did *per se* tend to stultify inventive progress and to lead to the pursuit of mere custom,

> Which all mankind to slavery brings
> That dull excuse for doing silly things.

Regarding the general policy of the various registration societies, he was not going to indulge in any invidious comparisons ; they were all honourable bodies, and very useful in their way. He had, however, in his mind's eye midship sections submitted years ago showing certain proposed details, and returned from headquarters with these flights of fancy ruthlessly scribbled over in sanguinary colours, and the direct veto, "as per rule," scrawled alongside ; yet many of these selfsame proposals are common practice nowadays.

Mr. Robert Thompson greatly advocated the use of Z bars for frames. The absence of rivets was an important desideratum, but where it is desired to do away with hold beams in large vessels it was not possible to get Z bars of sufficiently large section to give the requisite strength ; hence the girder frames had to be resorted to, but in smaller vessels they suited admirably. As to the saving of packing said to be secured by the adoption of the joggled plating, the figures given in the paper were those of the patentees, and are said to have been arrived at after careful calculation.

Mr. Arnison raised a question as to the practice regarding the filling in of the pocket spaces between the frames on the hold stringers at the shell. So far as his experience went shipbuilders did not fill in these spaces in the holds with wood and cement without extra charge unless they were specially specified. These pockets were very troublesome in coal and grain carrying ships.

In conclusion, he desired to thank the various gentlemen who were kind enough to take part in the discussion, and he trusted that when another decade had passed away there might be introduced in the interim further improvements in the details of ship construction, sufficiently important and numerous to warrant another paper to deal with them.

The PRESIDENT had great pleasure in moving a hearty vote of thanks to Mr. James for his excellent paper on "Some Structural Details of Modern Ships."

This was accorded by acclamation.

ADJOURNED DISCUSSION ON MR. R. M. FERRIER'S PAPER ON "ENGINES AT HIGH SPEEDS."

Mr. R. M. Ferrier, referring to the discussion on his paper "The Determination of the Forces which produce Vibration with Three-crank Engines at High Speeds," was afraid he had little to say in reply to the discussion, as scarcely any point was raised which lent itself to reply. Mr. Patterson's criticism had not gone into any point to which he (Mr. Ferrier) had to reply. In fact, Mr. Patterson dealt more with the question of the balancing of the engine with which, as he (Mr. Ferrier) was careful to point out, he was not in the least degree concerned. He took the engine as it was actually built, and tried to show the method which seemed to him best to find the forces involved. He was purely engaged with the forces involved and not with the actual balance produced, so as the question of the method had not been raised he felt he had scarcely anything to say. He had only to thank the members of the Institution for the way in which they had received the paper.

ADJOURNED DISCUSSION ON MR. A. E. DOXFORD'S PAPER "ON BALANCING HIGH SPEED ENGINES."

Mr. A. E. Doxford, in closing the discussion on his paper "On Balancing High Speed Engines," said he must thank them for the way in which they had received it. He thought that the only point there was to reply to was the one raised by Mr. Patterson that the Yarrow, Schlick, and Tweedy type of engine was easier to balance than the four-crank engine described in the paper. Not having had the opportunity of seeing this design of engine, he was unfortunately not in a position to answer Mr. Patterson's criticism, but he was sure they would all be glad to have a paper from him on this subject next session. Of course the engines of the "Haughty" and "Hardy" were merely given to illustrate the paper, not as examples of perfect balancing.

The President moved a hearty vote of thanks to Mr. Ferrier and Mr. Doxford for their papers.

This was accorded by acclamation.

CLOSING BUSINESS.

Mr. HUGH MACOLL moved, and Prof. R. L. WEIGHTON seconded, that Mr. R. W. Sisson be re-appointed Auditor.

Agreed.

NEW MEMBERS OF COUNCIL.

The PRESIDENT had much pleasure in intimating that Col. H. F. Swan had been unanimously elected President of the Institution for next year. Also, Mr. E. W. De Rusett, Mr. Henry Fownes, and Mr. James Patterson had been elected Vice-Presidents; Mr. G. E. Macarthy, Hon. Treasurer; and Mr. R. P. Doxford, Mr. Summers Hunter, Mr. M. C. James, Mr. W. G. Spence, and Mr. Robert Wallis, Ordinary Members of Council.

INSTALLATION OF THE NEW PRESIDENT.

The RETIRING-PRESIDENT said it was at once a painful and pleasurable duty he had now to perform, namely, to install his successor, and that meant making way for him in a presidency he had much enjoyed. At the same time, he could assure Col. Swan that it gave him great pleasure to make way for the new President, and he considered the Institution very fortunate in securing Col. Swan. It was not necessary, and, in fact, he might go a little farther, and say it would be a presumption on his part to attempt to enumerate the qualifications Col. Swan had to occupy the presidency of this Institution, or that he should advance them in Newcastle; but he had had the pleasure of knowing Col. Swan for a great number of years personally, and he could assure him that he could not have any greater pleasure than the duty that devolved upon him at that moment. He was quite sure in Col. Swan they had secured a President who would in every way maintain the dignity and character and influence of this Institution, and the high position it now occupied. As President, he had met many people and gone to many places, and he could assure them he had been no more astonished than delighted at the manner of his reception as their President. He could assure Col. Swan that he would be well backed up by a very able Council, who, if he had any tendency to go from the straight line would very soon bring him back, and have a very able adviser, as he had found, in the person of the

Secretary of the Institution (Mr. Duckitt). He thought the Institution must be in every way satisfied to have Col. Swan as their President. As they all knew, he had long occupied an eminent position in the shipbuilding world, and was a director of one of the greatest firms in this country, which stretched its arms all over the world. He could only hope that during his term of office he would enjoy it as much as he had done. He had no doubt that the affairs of the Institution in every way would continue to prosper while Col. Swan occupied the honourable position of its President.

Ald. Richardson shook hands with his successor, and vacated the chair in his favour.

The PRESIDENT (Col. Swan) said he need not say that he appreciated very much indeed the honour they had done him in electing him President of this Institution. He had some diffidence in speaking to them after the very flattering terms in which Mr. Richardson had referred to him. He had had the pleasure of knowing him for a great many years, and appreciated therefore all the more the kind words he had said. When he (the retiring President) was good enough to bring to his notice the desire of the Institution that he should accept this position, he certainly hesitated. He (the President) was at the inauguration of the Institution, now a good many years ago, and he had no idea then that it would grow to the importance it had since attained. Its expansion had been truly marvellous, and although it might not be expected to rank with the very old and tried associations in London, still there was no doubt that in the provinces, and on the North-East Coast here, it was carrying out a most important educational work. They did not pretend, he supposed, that they were members of this Institution merely for the sake of pleasure or as a pastime. He was sure that they all recognised that it was a means to an end, that they should, in meeting together, impart information to one another and raise the standard of scientific education in the neighbourhood so as to enable them to compete in the markets of the world for the trade by which they all lived. There was no doubt that one of the most formidable competitors they had at the present time was Germany. Now, it was well known that Germany had been in the forefront for a great many years with scientific education, and he firmly believed that a great deal of the success which had attended German enterprise, had been through that same scientific education, backed by dogged perseverance and good business qualities. Foreign competition was no myth nowadays, and the only way they could meet it was by fostering

scientific education, enabling them to turn out the highest quality of work at the lowest cost. That was the keynote they had to sound undoubtedly. He could only say that any services he could render to this Institution would be cheerfully given, and although he had got to follow some very eminent predecessors, which made it all the more difficult for him to fulfil his duty, still he would do his best, and rely, as Mr. Richardson had kindly pointed out, upon the assistance of the Council, who were really the hard-working part of the Institution, coupled with their Secretary, whose acquaintance he had had the honour of having for a great many years. He would not detain them longer that night, but merely again thank them for the great honour they had done him, an honour which, moreover, he felt carried great responsibility. However, he accepted it, and would do his best to further the interests of the Institution.

VOTE OF THANKS TO THE RETIRING PRESIDENT.

Mr. Wm. Boyd said he occupied a position that evening which he had occupied on more than one previous occasion, and he should like to endorse what had been remarked by Mr. Swan, that those who assisted at the formation of that Institution some twelve years ago had very little idea or expectation that it would reach the position it now occupied in the scientific world. Referring more particularly to their retiring President, he felt that they were particularly indebted to him for the services he had rendered to them during his term of office. During the last part of that period his attendance at the meetings of this Institution had, of course, been to a certain extent interfered with by calls in another direction; but he would submit that support to an Institution or to any cause might be given in various ways, and their retiring President had, to his knowledge, brought the position, and the influence, and the work of this Institution before their professional friends and the professional public in a way which he could not have done occupying any other position than that to which he had been elected and held in the House of Commons. If, as he said, some twelve years ago they had been told that amongst their Past-Presidents there would be two members of Parliament, he thought they should have been entitled to be slightly incredulous; and although the usefulness of the ordinary member of Parliament might be a matter of question, still, there was no doubt that so long as their domestic institutions existed it was extremely desirable that such an Institution as this should be adequately

represented. It was a matter of very extreme pride and satisfaction to themselves that they had been the means, indirectly, of course, the indirect means of educating two gentlemen to occupy such a distinguished position. He would not detain them longer except, perhaps, for one personal remark. He would not refer to his own connection with this Institution; but he might, perhaps, be excused for saying that their new President was his oldest and most intimate professional friend, and they had been intimately acquainted in business for more years than either of them would care to talk about, and therefore they could understand it was with the most extreme personal pleasure that he saw him in that chair, and as far as he (Mr. Boyd) was personally concerned, he felt sure he would receive the cordial assistance of members of Council, the Past-Presidents, and all those whose duty it was to assist him in the working of this Institution. He begged to ask them to join with him in a cordial vote of thanks to their retiring President.

The proposal was acceded to by acclamation.

Ald. RICHARDSON heartily thanked the meeting for the vote of thanks passed to him on retiring from the position of their President. He had this satisfaction in entering the lists of their Past-Presidents, that he joined some of the most honoured members of the engineering and shipbuilding professions on the North-East Coast. He forgave Mr. Boyd for the slight he threw out at the sitting members of Parliament, for he assured them he looked upon himself as a very ordinary member, but he thanked him for having said he had been enabled in some way to bring before engineers and shipbuilders in other parts of the world the value of this Institution. He could assure them he had felt when he had attended meetings and dinners as their President that it seemed in no way necessary that their President should have "M.P." after his name. Indeed, he had felt lately that it would be wise for the members of this Institution carefully to look to the man they were going to elect as their President that they should not hit upon one likely during his term of office to occupy that position, for though it must of necessity be his desire to fulfil his duties as President of their Institution, he must, in some measure, appear to neglect them. He could only assure them of this that during his term as President of their Institution he had done his very best to fulfil its functions. If he had at any time appeared to fall short in any way, it had not been for want of will or interest in the welfare of this Institution. He was very glad to have that opportunity of thanking the members for the courtesy and kindness they had at all times shown to

him during his term of office, and he would like to thank most heartily the members of Council, the members who had at different times during the term of his presidency occupied the position of chairman, for the kindly help and assistance they had always given him, and he would like to include in those thanks their worthy Secretary (Mr. Duckitt). He did not feel, although he had got out of the chair, that he had, as it were, passed out of having interest in this Institution. He had noble examples before him in Mr. Boyd and the President who had gone before him (Mr. R. Thompson), and others. They had shown him that after he had left the chair, he must still continue, as it would be his pleasure, to take great interest in this Institution. He was satisfied to think that he should, during the next month, have the honour of representing their Institution in the trip they were going to make to Cardiff. As they all knew last year they had no summer excursion. He did not know how that was, he thought, perhaps, the general election that took place put such things out of their heads, at any rate they were going to make up for it this year, and he hoped as many members of the Institution as possible would make it their endeavour to be present. It was unfortunate that their new President would be called to other duties just at that particular time. He believed Col. Swan would be serving his country in another manner. He was rather thankful for that, as he should have the pleasure of going to Cardiff in his stead, and of endeavouring to fulfil to the best of his ability the duties which would not otherwise have devolved upon him. He thanked them again for the hearty vote of thanks accorded.

THE RETIRING MEMBERS OF COUNCIL.

Mr. Heck said he had just been asked by the Secretary to propose a vote of thanks to the members retiring from the Council. He might say that several gentlemen had already done that. He was also present at the first meeting of this Institution, and he could not help thinking, when so many referred—and rightly referred—to the value of this Institution, a great deal of that was due to the members of Council, and he proposed to illustrate that by something which applied to the efforts of the gentlemen who ruled the Institution. There was an old Greek story which told of an occasion where the Athenians were assembled. When the building was quite crammed an old man came in and looked hither and thither, but was unable to find a resting place until he came to where the Spartan ambassadors were seated, when the whole of them jumped up and offered

him a seat. The Athenians, who noticed the gracious act, filled the place with applause. "Ah!" said an ambassador, "the Athenians know what is right, but they don't do it." Now, the retiring Councillors not only knew what was the right thing to do, but they did it; and he had therefore very great pleasure in proposing a vote of thanks to the retiring members of Council.

The vote was cordially given by acclamation.

THE SESSION CLOSED.

The PRESIDENT said the only remaining thing to be done that evening was for him to formally declare the session closed. As they knew, the Institution would meet at Cardiff on a pleasure excursion. He might say, as he happened to be there a year or two ago with the Institute of Naval Architects, he could assure them of a good reception, and would find things of very great interest there. It was a new town, comparatively speaking, and everything seemed to be growing at a great rate. They would find there very large works—steel works, and so on—and he could assure them they might look for a very interesting time. He was only sorry he should not be able to be there himself, as he had to be in camp at Whitley during the race week. However, Mr. Richardson had kindly promised to look after them, and he was sure they would have no cause to regret the change for the occasion. He now declared this session closed.

The meeting then dissolved.

REPORT OF THE REPRESENTATIVES ON LLOYD'S TECHNICAL SUB-COMMITTEE.

We, the members of Lloyd's Technical Sub-Committee, elected by the North-East Coast Institution of Engineers and Shipbuilders on the 13th October, 1890, think it due to the members of the Institution to give a brief report of the work done since we were honoured by being elected your representatives.

24th March, 1891.

At this meeting of the Technical Sub-Committee, a letter from one of our members was read giving notice that the weights of stud chain cables given in the new tables, 1890-1, be amended, as they did not correspond with recent practice which had been approved by the general committee. It was pointed out that the weights of cables, as given in the new tables, were much in excess of current practice; and as this extra weight was not considered necessary for safe working, after discussion it was agreed that the member should furnish full particulars of average weights. Chain Cables.

Rules for obtaining the scantlings of large sailing vessels were submitted by the Chief Surveyor, and the Sub-Committee agreed to recommend the several proposals to the General Committee for approval. Scantlings of Sailing Vessels.

A discussion occurred as to the height of engine and boiler casings on awning decks, and it was eventually agreed to confirm the wording of paragraph 4, section 29, on this subject. E. and B. Casing.

The Chief Engineer-Surveyor submitted certain proposals with a view of the amendment of rules (section 48) for the survey of engines and boilers. Those relating to the rules for boilers were adopted, with the addition of certain suggestions made by members of the Sub-Committee. Survey of Engines and Boilers.

The new rules for sizes of shafting, and for the use of cast steel, were referred back to the Chief Engineer-Surveyor for further consideration. Shafting.

21st July, 1891.

Chain Cables.

Minimum weights of chain cables.

This question came up again for consideration at this meeting, a diagram being shown illustrating the difference between the scale of minimum weights and the current practice. The matter was again deferred.

Survey of Engines and Boilers.

The amended rules submitted by the Chief Engineer-Surveyor for the periodical survey of engines and boilers, size of shafts, and use of steel castings, were adopted by the Sub-Committee with some slight modifications.

Strength of Boiler Shells.

The proposal of two of the technical members of the Sub-Committee, that the Chief Engineer-Surveyor be requested to consider the propriety of modifying the rules at present in force for the strength of boiler shells, was adopted.

5th April, 1892.

Chain Cables.

The discussion on the table of minimum weights of cables deferred from the last meeting, after consultation with the chain-makers, was again brought up, and a table of minimum weights was approved, being considerably less than originally inserted in the rules, and more in accordance with current practice. The committee had before them a proposal to amend the rules relating to the size of beams, making the upper-deck beams in main and spar-deck vessels the same size as the main-deck beams.

Beams.

As this proposition had nothing to recommend it, except that it would secure a uniform size of beams, the Sub-Committee rejected the proposal.

Several other matters of minor importance were discussed at this meeting.

Pumps.

Regulations as to the fittings of independent feed pumps in the engine room, and as to the connections for feed and ballast pumps, were agreed upon.

Boiler Shells.

The question of the rules for the strength of boiler shells came up for discussion, and eventually a new formula was agreed upon, the effect of which would be to reduce the thickness of boiler shells about 8½ per cent.

Furnaces.

Formula for the strength of furnaces were also considered, and it was agreed that the same rules should apply to Fox and Morison furnaces.

25th October, 1892.

On account of steel plates failing whilst being flanged cold it was considered necessary to amend the rules for testing steel plates, so as to secure a more uniform quality of steel for shipbuilding purposes. Cold Flanging.

A proposition to this effect was submitted for the Sub-Committee's consideration, and after discussion it was deferred until their next meeting, the 21st March, 1893, when it was agreed that cold bend tests should be taken from all plates when it is known they are to be flanged.

21st March, 1893.

A proposition relating to the rules for raised quarter-deck ships was considered. The Chief Surveyor proposed that the main-deck should be scarphed two or three frame spaces at the break, and a number of diaphragm plates fitted. Although, as pointed out, this arrangement would break up a lot of stowage the amendment was eventually agreed to, as the majority of the members considered that this type of vessel was not strong enough at the break of the raised quarter-deck. Quarter-deck Ships.

At the same meeting it was also recommended to the General Committee for approval that the floor plates and other parts of the inner bottom in the boiler space should be increased in thickness. Floor Plates.

They also considered the proposal by one of the members for regulating the size of boat davits and anchor cranes, and recommended the same to be approved. Boat Davits, Anchor Cranes.

28th November, 1893.

The surveyors submitted that in order to obviate the necessity of renewing a sound wood deck, when slightly worn below the limits of the rules, it was desirable to amend the rules so as to definitely state when a deck should be renewed. Wood Decks.

The proposition was carried, as was also one relating to the minimum thickness of wood sheathing when fitted on an iron or steel deck.

13th March, 1894.

At this meeting a formula for finding the diameter of rudder heads was proposed by one of the members and agreed to. Rudder Heads.

Quality of Steel.

Quality of steel for shipbuilding purposes. The Chief Surveyor submitted an amendment proposing to increase the elongation limit from 16 to 20 per cent. After some discussion this was agreed to.

Sluice Valves.

After considerable discussion, occasioned by the remarks of the Chief Surveyor, relative to fitting sluice valves on watertight bulkheads, it was agreed that a paragraph should be inserted in the rules leaving it optional whether these are fitted or not. Many shipowners objected to the valves being fitted, stating that there is always a danger of the water present in the engine room bilges finding its way through the sluice valves into the holds, thus damaging the cargo.

24th July, 1894.

Testing Decks

The Chief Surveyor proposed that a new paragraph be added to the rules, requiring that main and weather-decks, when completed, to have their watertightness tested by a hose in the presence of the surveyors, who had to state in their first entry report the result of these tests.

This paragraph met with the approval of the Sub-Committee, and was recommended to the General Committee for acceptance.

Electric Light.

Rules for electric light on board of vessels were submitted at this meeting, and deferred.

Several other matters were also discussed and deferred.

4th December, 1894.

Testing Decks.

The resolution agreed to at the last meeting, that all *main* and *weather*-decks should be tested was altered to read all *upper* and *weather*-decks.

Electric Light.

The proposed rules for use of electric light on board of vessels again came up for discussion.

After considerable discussion they were amended, and recommended to the General Committee for approval.

Boilers.

Rules for the butt straps of shells of boilers, and for corrugated, ribbed, and other furnaces, were adopted.

2nd April, 1895.

Deep Framing.

The Sub-Committee considered a proposal, submitted by the Chief Surveyor, that a new section be added to the rules

providing definite requirements for vessels constructed with deep frames in lieu of hold beams and web frames. Although a number of vessels had been built with this system of framing, there was no table for the size of frames and stringers.

It was considered that the proposed scantling was of suitable sizes, and would give as much strength as with other systems of framing. The addition to the tables was, therefore, with slight amendment, unanimously agreed to.

Sectional Iron.

Proposals having been made by the steel-makers with a view to obtain unanimity in the size and form of bulbs, tee bulbs, and angle bulbs, the Chief Surveyor's remarks upon these proposals were set forth, with proposed sketches to be inserted in the rules, and the Sub-Committee concurred in the proposals.

12th November, 1895.

Three-deck Vessels.

Proposed addition of a new paragraph relating to vessels built to the three-deck rule, with the wood middle-deck omitted, was submitted for discussion at this meeting.

The effect of this paragraph was to make a compulsory freeboard the condition of the classification.

It was proposed to penalise the ship in freeboard for dispensing with the wood middle-deck

The members not approving of this, the subject was deferred until the next meeting.

18th February, 1896.

Three-deck Vessels.

The proposed new paragraph penalising the freeboard in vessels built to the three-deck rule came up for discussion, and by some misunderstanding it was agreed that the wood middle-deck could be dispensed with, and the normal freeboard retained by taking the numbers without the 7 feet deduction for three-deck rule.

24th March, 1896.

Three-deck Vessels.

Rule relating to the omission of the wood middle-deck.

A proposition was submitted to alter the rule agreed at the last meeting, and after considerable discussion it was agreed that a suitable paragraph be inserted in the rules defining in what manner the strength could be made up.

It was agreed that in such vessels the frames and reverse frames only should be taken to a number without the 7 feet deduction, if the normal freeboard were desired.

Spar-deck Vessels.

It was further pointed out that in spar-deck vessels of small depth, in proportion to the length, the number and thickness of iron decks and the thickness of the topside plating were required by the rules to be greater than those of a three-deck ship of the same dimensions.

This was considered unfair (inasmuch as the spar-deck ship has a greater freeboard than the three-deck ship), and an addition to the rules was proposed, stating that in no case need the thickness and number of steel or iron decks and the material at the upper part be greater than a three-deck ship of the same dimensions.

The Chief Surveyor recommended this addition, and the same was agreed to.

Bulkhead Liners.

A sketch was also submitted of a proposed diamond-shape bulkhead liner, which was agreed to.

Turret Ships.

Proposed rules submitted by the Chief Surveyor for obtaining the scantling numbers in turret-deck vessels were under consideration.

7th July, 1896.

Turret Ships

The proposed rules for turret vessels were brought up for discussion at this meeting, and, with slight modifications, the Chief Surveyor's proposals were agreed to.

The foregoing, though not comprising all, are the principal items that have been considered.

(Signed) W. Boyd.
F. C. Marshall.
R. Thompson.
H. Withy.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

TWELFTH SESSION, 1895-96.

SUMMER MEETING,

HELD AT CARDIFF, JUNE 23RD, 24TH, 25TH, AND 26TH, 1896.

OFFICIAL PROGRAMME.

In response to an invitation received from the following large and important body of gentlemen representing Cardiff and the Bristol Channel ports, the first Summer Meeting of the Institution was held in Cardiff, commencing on Tuesday, June 23rd, 1896.

RECEPTION COMMITTEE AT CARDIFF.

President—THE RIGHT HON. LORD WINDSOR, Mayor of Cardiff.
Chairman—*C. A. HEYWOOD.

Committee—

THE MOST NOBLE THE MARQUIS OF BUTE, K.T.
THE HON. MAJOR WYNDHAM-QUIN, M.P.
SIR W. T. LEWIS, BART.
SIR W. D. PEARSON, BART., M.P.
G. T. CLARK, J.P., Talygarn.
J. M. MACLEAN, M.P.
D. A. THOMAS, M.P.
R. FORREST, J.P., D.L.
T. R. THOMPSON, J.P.
*LEWELLEN WOOD, J.P.
J. GUNN, J.P., President of Cardiff Chamber of Commerce.
*W. R. CORFIELD, President of Cardiff Incorporated Shipowners.
PRINCIPAL V. JONES, Principal of Cardiff University College.
*H. W. MARTIN, President of South Wales Institute of Engineers.
*T. E. WATSON, J.P., President of Newport Chamber of Commerce.
*PROFESSOR A. C. ELLIOTT, D.Sc., President of the Bristol Channel Centre of the Institute of Marine Engineers.
*J. F. WALLIKER, Hon. Sec.

* Members of Executive Committee.

*M. W. Aisbitt.
W. Anning.
*H. Y. Adye.
*A. Beasley.
W. G. Blow.
*Alderman Carey, J.P.
J. H. Carney.
Lascelles Carr, J.P.
J. R. Christie.
Alderman R. Cory, J.P.
John Cory, J.P.
John Cory, J.P.
*W. J. Darling.
Ed. Davies, J.P.
David Duncan, J.P.
*R. Evans.
*J. B. Ferrier.
Col. H. O. Fisher.
T. Forster Brown.
*R. A. Foster.
*David Gibson.
*M. Gunn.
*J. H. Hallett.
C. L. Hunter.
A. K. Hamilton.
Ed. Handcock, J.P.
*Ed. Handcock, Jun.
A. Henshaw.
*J. Hurman.
A. Hood, J.P.
J. A. Jones.
Alderman D. Lewis, J.P.
*John Lowden, J.P.
E. P. Martin, J.P., C.C.
J. Moore.
P. Morel, J.P.
*Councillor T. Morel, J.P.
M. Mordey, J.P.
E. R. Moxey, J.P.
*Henry Radcliffe.
*T. H. Riches.
W. Riley, J.P.
*H. J. Simpson.
*W. Simpson.
P. A. Vyvyan-Robinson.
Capt. T. N. Rosser.
G. Rutherford.
*C. L. Ryder.
*G. Sloggett.
*C. E. Stallybrass.
A. J. Stevens.
*G. F. Stuckey.
W. H. Taylor.
Councillor Trounce, J.P.
G. J. Twigden.
P. Turnbull, J.P.
*T. W. Wailes.
*J. L. Wheatley, Town Clerk.
J. H. Wilson.

* Members of Executive Committee.

Reception Committee at Newport (Monmouthshire).

President—The Right Hon. Lord Tredegar.

Chairman—J. H. Carney.

Committee—

His Worship the Mayor of Newport.

Col. the Hon. F. C. Morgan, M.P. Albert Spicer, M.P.

T. E. Watson, J.P., President Chamber of Commerce.

Colonel Lyne, J.P.

J. E. Ward, Chairman Newport Harbour Commissioners.

Alderman Henry John Davis, J.P.

W. D. Arthur.
H. H. Ashton.
C. H. Bailey, J.P.
J. W. Beynon.
T. A. Hawkes.
A. Henshaw.
G. H. Hopkins.
L. H. Hornby.
L. G. Laurie.
R. Laybourne, J.P.
A. Levison.
M. Mordey, J.P.
L. B. Moore.
W. J. Orders.
Capt. R. B. Pugsley.
C. D. Phillips, J.P.
J. W. Shotton.
A. J. Stevens, J.P.
R. Williamson.
J. H. Winn.

John Boddy, Hon. Treas., 68, Dock Street.

T. C. Calder, Hon. Sec., Newport Engineering Works.

The following is a copy of the Official Programme of Proceedings as supplied to the members :—

TUESDAY, JUNE 23RD.

At 10 a.m.—Reception of the members in the Council Chamber, Town Hall, Cardiff, by the Right Hon. Lord Windsor, Mayor of Cardiff; John Gunn, J.P., President of the Cardiff Chamber of Commerce; W. R. Corfield, President of Cardiff Incorporated Shipowners; and the Chairman and Members of the Reception Committee.

At 11 a.m.—Leave Cardiff (G.W.R.) by special train direct for Alexandra Dock, Newport, where the members will be received by the Right Hon. Lord Tredegar, President of the Newport Reception Committee; Albert Spicer, M.P.; T. E. Watson, J.P., President of the Newport Chamber of Commerce; and other Members of the Local Reception Committee. After inspection of Docks, brakes will be provided to take the party to different works and places of interest.

At 1·30 p.m.—Luncheon at Tredegar Hall, by invitation of the Newport Reception Committee.

At 3·30 p.m.—Embark by invitation of Harbour Commissioners at their Pontoon, on board Saloon Steamer, for inspection of River Usk, etc., and land at Cardiff about 5·30 p.m.

WEDNESDAY, JUNE 24TH.

At 10·0 a.m.—Leave Rhymney Station, Cardiff, by special train provided by Messrs. The Bute Docks Co., for Dowlais Steel Works, leaving the Steel Works at 11·45 for the Pier Head and Docks.

At 1·30 p.m.—Luncheon at the Site of the New Dry Dock, by invitation of Messrs. The Cardiff Channel Dry Docks and Engineering Co., and Messrs. S. Pearson and Son, contractors.

At 3·0 p.m—Visit Exhibition at Cardiff.

At 8·0 p.m.—Smoking Concert at the Park Hall, by invitation of the President and Members of the Bristol Channel Centre of the Institute of Marine Engineers.

THURSDAY, JUNE 25TH.

At 10 a.m.—By the kind permission of the President and Council of the South Wales Institute of Mining Engineers, the Summer Meeting of the Institution for reading and discussion of papers will be held at their Institute, Park Place, Cardiff, when the following papers will be read and discussed, viz. :—"Notes on the Maintenance and Repair of Marine Boilers," by John F. Walliker, member; and "Marine Boilers, particularly in reference to Efficiency of Combustion and Higher Steam Pressures," by J. R. Fothergill, Vice-President. Alderman Thomas Richardson, B.A., M.P., Past-President of the North-East Coast Institution of Engineers and Shipbuilders, will occupy the chair.

At 12 noon.—Leave Queen Street Station by special train, kindly provided by Messrs. The Taff Vale Railway Co., for Penarth Dock and Barry Dock.

At 1·30 p.m.—Luncheon by invitation of Messrs. The Barry Graving Dock and Engineering Co., Ltd., afterwards inspecting the dock works, deep sea lock, and other works.

At 5 p.m.—Return from Barry.

This evening will be free, and members can make their own arrangements.

FRIDAY, JUNE 26TH.

At 9·45 a.m.—Leave the Pier Head, Cardiff, per saloon steamer "Cambria," for Ilfracombe.

At 1·30 p.m.—Lunch at the Ilfracombe Hotel, by invitation of the Cardiff Reception Committee.

At 4·30 p.m.—Leave Ilfracombe for Cardiff.

WORKS OPEN FOR INSPECTION.

NEWPORT (MONMOUTH) (see pages 209 *et seq.*).

R. Arthur & Son, Newcastle Engine Works.
C. H. Bailey, Tyne Engine Works.
L. G. Laurie & Co., Engineers, etc.
Mordey, Carney, & Co., Ltd., Shipbuilders and Dry Docks.
Newport Electric Light Supply Station.
Newport Engineering and Ship Repairing Co., Ltd.
Newport Ropery Co., Clarence Road.
C. D. Phillips, Emlyn Engineering Works.
Richards & Hopkins, Britannia Engine Works.
South Wales Brattice Cloth and India Rubber Co., Ltd.
Thompson & Hawkes, Wear Engine Works.
Union Dry Docks Co., Ltd., Graving Docks.
Uskside Engineering and Rivet Co., Ltd.

CARDIFF AND DISTRICT (see pages 214 *et seq.*).

The Dowlais Iron Works, Cardiff.
The Mount Stuart Shipbuilding, Graving Dock, and Engineering Co.'s Works.
The Bute Shipbuilding, Engineering, and Dry Dock Co.'s Works.
The Cardiff Junction Dry Dock and Engineering Co.'s Works.
The Tydvil Engineering Co.'s Works.
Equilibrium Piston Co.'s Works.
The Mercantile Pontoon Co.'s Works.
The Tyneside Engine Co.'s Works.
Messrs. Mordey, Carney, & Co.'s Windsor Slipway and Central Engineering Works.
Hills' Dry Dock and Engineering Co.'s Works.
G. E. Fownes & Co.'s Works.
C. H. Bailey's Works.
Union Dry Dock Co.'s Works.
The Barry Graving Dock Co.'s Works.
The Penarth Shipbuilding and Ship Repairing Co.'s Works, Penarth Dock.
The New Deep Sea Lock at Barry is worthy of attention.

Any member desiring to visit one of the collieries in the district may arrange to do so by communicating with the Hon. Secretary of the Executive Committee at Cardiff.

PROCEEDINGS.

TUESDAY, JUNE 23RD, 1896.

The first Summer Meeting of the Institution was opened at Cardiff, on Tuesday, June 23rd, 1896.

At 9 a.m. the Mayor (Lord Windsor) entertained the Council of the Institution to breakfast at the Angel Hotel, and the visitors were joined by Mr. Lewellen Wood, Mr. Charles A. Heywood (Chairman of the Cardiff Reception Committee), Mr. J. F. Walliker (Hon. Secretary and Past Vice-President of the Institution), Alderman David Jones (Deputy-Mayor), and Alderman Carey (ex-Mayor).

At 10 o'clock an official reception of the members of the Institution was held in the Assembly Rooms of the Town Hall by the Mayor (Lord Windsor), who was supported by the Deputy-Mayor, ex-Mayor, and the majority of the Aldermen and Councillors of the Corporation, while among the local gentlemen were Mr. John Gunn (President of the Chamber of Commerce), Mr. Lewellen Wood, Mr. Charles A. Heywood (Chairman of the Cardiff Reception Committee), Mr. J. F. Walliker (Hon. Secretary of the Cardiff Reception Committee), Capt. W. R. Corfield (President of the Shipowners' Association), Mr. Marcus Gunn, Mr. C. L. Ryder (Hon. Treasurer of the Bristol Channel Centre of the Institute of Marine Engineers), Mr. T. W. Wailes, etc.

Amongst those present were Mr. Thomas Richardson, M.P., West Hartlepool, Acting-President of the Institution; Mr. Robert Thompson, Past-President; Mr. Hugh Macoll, Sunderland; Mr. J. R. Fothergill, West Hartlepool, and Mr. J. Gravell, Chief Surveyor of the Bureau Veritas, Vice-Presidents; Mr. G. E. Macarthy, Newcastle, Hon. Treasurer; Mr. John Duckitt, Newcastle, Secretary of the Institution; Mr. H. H. Wake, Chief Engineer to the River Wear Commissioners; Col. Bingham, Sheffield; Mr. Charles Thompson, Sunderland; Mr. R. Hirst, Lloyd's Register, West Hartlepool; Mr. G. H. Baines, West Hartlepool; Mr. Campbell (Messrs. Robert Stephenson & Co.), Newcastle; the editor of the *Engineer;* Mr. Frank Graham, Newcastle, etc.

Lord WINDSOR (who was formally introduced by Mr. C. A. Heywood) said that among the many pleasant duties the chief magistrate of a town like Cardiff had to perform were those of welcoming such bodies as that represented by the present gathering. He felt that no more important body than that to the members of which he now extended a hearty welcome

could visit Cardiff. They represented two important industries—shipbuilding and marine engine construction—without which the resources of the South Wales coal-field would be practically useless. They looked to the ships to carry their coal away, and to the engineers to give them those modern improvements so necessary to keep England in the forefront of commercial nations.

Alderman T. RICHARDSON, M.P., acknowledged the reception of the Mayor, and, referring to an observation made by Mr. Heywood, he remarked that Cardiff had been an excellent customer to them, and there was, therefore, a special reason why they should feel interested in visiting Cardiff. The Mayor had spoken of the large increase of population in Cardiff, and they were proud to think that they in the north country had a good deal to do with that increase, as there were so many of the inhabitants of Cardiff who hailed from the north country.

Mr. JOHN GUNN also welcomed the Institution, and in the course of his remarks said there were ample facilities on the shores of the Bristol Channel for shipbuilding, and it only wanted the intelligence, industry, and capabilities of the northerners to put those facilities to the best use. Therefore, he hoped some of them had come to survey the land, and to stop altogether.

Light refreshment, supplied by the Mayor, having been partaken of, the party left for the Great Western Railway Station, where they embarked on a special train for Newport, conducted by Mr. Calder, the Hon. Sec. of the Newport Reception Committee.

This train was taken direct to the Alexandra Docks, *via* Maesglas Junction, and arrived at the south-west corner of the dock at 11·45. (See Plate XLVI.) Here the company were met and received by Colonel Lyne, local director of the docks; Mr. Henshaw, general manager; Mr. W. S. Smyth, managing engineer; Mr. Albert Spicer, M.P. for the boroughs; Mr. T. E. Watson, President of the Newport Chamber of Commerce; Mr. J. H. Carney, Chairman of the Newport Committee; Mr. T. W. Pearson, docks engineer; Mr. M. Mordey, Councillor J. H. Dunn, Mr. Flanders, Mr. G. H. Thomas, Mr. C. H. Bailey, Mr. R. Williamson, Mr. T. A. Levison, Mr. T. A. Hawkes, Captain Partitt, dockmaster; Captain Pugsley, harbour master; Mr. A. J. Phillips, clerk to the Harbour Commission; Mr. E. J. Summers, clerk to the Pilotage Commission; and other public personages. A tour of the docks was made, showing the new coal-shipping appliances.

Afterwards the whole company was driven in open carriages, provided by the Newport Committee, to the various works open for inspection (see pages 209 *et seq.*).

At 1·30 the party sat down to luncheon at the Tredegar Hall, where a *recherché* spread was provided by Mr. S. Dean, of the Westgate Hotel. Mr. Albert Spicer, M.P., presided, and was supported by Mr. T. Richardson, M.P., Colonel Lyne, J.P., Messrs. T. E. Watson, J.P., R. Thompson, J.P., J. H. Carney, C. A. Heywood, W. E. Heard, J.P., M. Checchi, H. Macoll, J. R. Fothergill, H. Fownes, J. Gravell, H. H. Wake, G. E. Macarthy, J. Duckitt, H. J. Parnall, J.P., A. Henshaw, J.P., J. F. Walliker, and F. Graham. Amongst the general company were Messrs. M. Mordey, J.P., A. J. Stevens, J.P., C. H. Bailey, J.P., R. Williamson, L. G. Laurie, A. Levison, W. D. Arthur, H. H. Ashton, T. A. Hawkes, E. J. Summers, A. J. Phillips, Captain Pugsley, etc.

In proposing "The Queen," the CHAIRMAN said that Her Majesty had now entered a year of her reign which, if it were completed, would mean that she had reigned longer than any other English sovereign. They devoutly prayed that Her Majesty would live for many other years to come.

In proposing "The Visitors," Mr. A. SPICER, M.P., said that he regretted that he found himself in the position of Chairman of that day's proceedings, a position that should have been occupied by his friend, the President of the Newport Reception Committee, Lord Tredegar. He would be the first to admit that the position that he occupied should be properly occupied by Lord Tredegar. As chairman of the company under which the chief industry of the town and neighbourhood was carried on, it would have been right and proper that Lord Tredegar should have occupied the chair that day, but beyond that they recognised that apart from the high position that Lord Tredegar occupied in the neighbourhood, he was one who also recognised the responsibilities and trusts that were connected with it. No one recognised more than he (Mr. Spicer) did the splendid services that Lord Tredegar always aimed to render for the benefit of his countrymen in so many ways. In extending a hearty welcome to the visitors, he (Mr. Spicer) said that their business that day was to see what was being done in a town that was determined to go ahead, and that had already done something, as would be understood by the signs of enterprise that had been seen by the visitors that day. They had seen the accommodation offered in the docks, which was sufficient

It was agreed that in such vessels the frames and reverse frames only should be taken to a number without the 7 feet deduction, if the normal freeboard were desired.

Spar-deck Vessels.

It was further pointed out that in spar-deck vessels of small depth, in proportion to the length, the number and thickness of iron decks and the thickness of the topside plating were required by the rules to be greater than those of a three-deck ship of the same dimensions.

This was considered unfair (inasmuch as the spar-deck ship has a greater freeboard than the three-deck ship), and an addition to the rules was proposed, stating that in no case need the thickness and number of steel or iron decks and the material at the upper part be greater than a three-deck ship of the same dimensions.

The Chief Surveyor recommended this addition, and the same was agreed to.

Bulkhead Liners.

A sketch was also submitted of a proposed diamond-shape bulkhead liner, which was agreed to.

Turret Ships.

Proposed rules submitted by the Chief Surveyor for obtaining the scantling numbers in turret-deck vessels were under consideration.

7th July, 1896.

Turret Ships

The proposed rules for turret vessels were brought up for discussion at this meeting, and, with slight modifications, the Chief Surveyor's proposals were agreed to.

The foregoing, though not comprising all, are the principal items that have been considered.

(Signed) W. Boyd.
F. C. Marshall.
R. Thompson.
H. Withy.

for some of the largest vessels afloat. As to the Newport Alexandra Docks, he ventured with some pride to mention a few figures. To show the work done on March 31st (one day), no less than 21,851 tons of coal were shipped. In the month of August, 1894, no less than 80,008 tons were shipped. In 1894, 3,170,359 tons of coal were shipped. Since that time two additional hoists had been added, which would ship half a million tons of coal per annum. This year they had seen the shipment of a large cargo of coal on board the "Algoa," when no less than 11,671 tons of coal were shipped in 36 hours 45 minutes. As to the river, they had 4½ miles of 1,000 feet in width, adaptable for the largest vessels. Not only had all these advantages been provided and taken advantage of by private enterprise, but he was glad to find that the authorities in the town had done all they could to back up those efforts. The Harbour Commissioners were always doing what they could to see that the river was kept properly dredged and obstructions removed. Then they had the corporation, which he described as being in a state of restless activity. They had acquired the waterworks, the tramways, and the splendid electric light works that they had seen that morning. In addition, they had, aided by the generosity of Lord Tredegar, provided an excellent park. In every way, whether in extension of the borough, or anything else, the corporation was always doing its best to make Newport one of the most desirable towns to live in. There was a splendid area for improvement, as they had seen on the east side of the river, which was the natural outlet for the great industries of Monmouthshire, and also for the adjacent counties, as well as for conducting an important import trade for the whole of a very large district.

Mr. T. Richardson, M.P., said it was his pleasing duty to return thanks, first of all for the very kind way in which Mr. Spicer had welcomed them to Newport, and also for the more than pleasant time they had already spent in the town. He thought that there was one thing they ought to be rather wary about. That morning the temptation had been held out to them that they should come down to Cardiff and set up shipbuilding and engineering works; then they came on to Newport, and the same temptation was insidiously held out to them. It was true that many northeners had been tempted away from the north, and one pleasant part of their visit was the meeting of old friends. He supposed they found that, with their capabilities, the north was too small for them. From the very moment that they got out of the train, and Colonel Lyne and Mr. Henshaw met them, they had kept them going about seeing

something of interest; and whilst on the one hand they might applaud what was being done, they might almost wish that they were not quite so expeditious as Mr. Spicer had told them they were in the shipping of coal, because they made one steamer do the work of two or three, and so the north did not have so much to do in the shipbuilding line. Still, they had foreign competition to face, and unless they went ahead and adopted all the improvements that they possibly could, they would always have the fear before them that they might in the future fall behind. But he thought, with the spirit that had been shown by the people of Newport, there need be little fear of that. He would like to express their very hearty thanks to the Reception Committee for having organised such a very pleasant day. They had all been struck with the progress that was taking place in Newport; and, if he might be pardoned for saying so, they had a sign of progress in that hall. They were met together in a Conservative hall, and he had on his left a fellow-member who sat on the other side of the House, and on his right another gentleman who had always been a staunch Liberal. After all, it was remarkable about politics in this country that they always agreed to differ. When the fight was on they ranged on different sides, but when all was over they could work hand in hand for the progress and prosperity of the country.

At this juncture the CHAIRMAN read a letter from the Town Clerk of Newport, stating that the Mayor had been detained in Bath on account of his wife's illness. Also, a telegram from Mr. C. D. Phillips, from the Leicester showyard, wishing the visitors an enjoyable time.

Mr. RICHARDSON then asked permission to propose a toast which was not on the programme, viz., that of "The Reception Committee." He thought they would agree with him that the reception they had met with had been one that had required a great deal of thought and care, and could not be surpassed anywhere. He coupled with the toast the name of Mr. J. H. Carney.

The guests drank the toast with musical honours and cheers, and Mr. CARNEY briefly responded, expressing the feeling of the committee that they had been actuated by a desire to interest their visitors and provide them with an enjoyable day.

Col. LYNE said that he had been asked to propose another toast, one he ventured to think that they would indeed be ungrateful if they omitted. He meant the toast of the Chairman. He could assure Mr.

Spicer that he had a very hearty welcome even in that Liberal-Unionist hall, and the oftener they could see him there on similar occasions the better. Indeed, he had spoken so kindly and so well of Newport that the inhabitants would be ungrateful in the extreme if they did not convey to him their appreciation of the honour and kindness he had done them on presiding on that occasion. Mr. Spicer had the heartiest good wishes of all the inhabitants of the town.

The toast was cordially drunk.

Mr. SPICER, in responding, thanked Col. Lyne for the very kind way in which he had offered the toast, and the company for the cordial way in which they had accepted it. It had been a source of great satisfaction that his first visit to the Tredegar Hall should be in connection with a subject that practically bound them all together. They had their party differences, and he supposed they always would have. He did his best to fight those differences without bringing in personalities, and he was thankful to say that as far as he knew, he had not made a personal enemy in these boroughs Occupying as he did that position, he was thankful to be of the smallest benefit to the boroughs in connection with the visit of their friends from the north. He trusted that the commerce of Newport might ever increase, and that when they came into competition with other ports and other districts, it would not mean individual harm to anyone.

In the afternoon the visitors embarked on the saloon steamer "Lady Margaret," by invitation of the Newport Harbour Commissioners, and went for a cruise down the River Usk and along the Monmouthshire coast to Cardiff. Before disembarking, Mr. R. THOMPSON, of Sunderland, expressed, on behalf of the northeners, the great thanks they felt to the Harbour Commissioners for giving them the opportunity of seeing the coast by water. Col. LYNE replied. The Newport Town Band, which had played during the luncheon and on board the steamer, then struck up "Auld Lang Syne," and, with a parting cheer, the visitors disembarked at the Cardiff pier-head. The "Lady Margaret" steamed out into the channel again, and gave the Newport people a run round the Flat Holm before heading for the mouth of the Usk.

WEDNESDAY, JUNE 24TH, 1896.

In accordance with the official programme the whole of this day was spent in Cardiff. The company, conducted by Mr. C. A. Heywood, Mr. John F. Walliker, and other members of the Reception Committee, left the Rhymney Station in a special train for the Dowlais Works on Wednesday morning (see Plate XLVII.). This road to the now famous iron and steel works gave ample opportunity of obtaining a brief outline of the enormous trade that is done at Cardiff. The line to the works runs over a vast network of railways, upon which there is a constant flow of traffic to and from the dock sides; and in the vicinity are numerous works of a more or less important character distributed over the East Moors, which gave the visitors some idea of the enormous trade transacted by the port. When the party arrived at the Dowlais Works (see page 214), they were received by Mr. E. P. Martin, manager of the Dowlais undertaking, who, with the aid of Mr. James, the Cardiff Works' manager, explained the various processes of iron and steel-making. The No. 3 furnace was tapped, and released some 35 tons of pig iron, representing the smelting of four hours, which were run out of the furnace into the sand moulds. From the furnaces the party made their way to the engine house, where the engines which drive the hot blasts for melting purposes into the furnaces won the admiration of everyone. This concluded, with the exception of some minor matters, the inspection of the iron works, and the visitors wended their way to the steel works. Here about 35 tons of steel were taken in a molten state from one of the Siemens furnaces, and the process of turning the raw steel into marketable stuff was exhibited by taking one of the heated ingots of steel from the soaking pits and putting it through the cogging process. The further stages of steel-plate making were shown by one of these ingots being taken from the furnace, where it had been reheated, and rolled into plates for Her Majesty's cruiser which is now being built at Pembroke Dock.

Before rejoining the train for the Bute Docks, Mr. T. RICHARDSON, M.P., thanked Mr. Martin for the courtesy he had shown them in conducting the party round the works, and also extended the thanks of the party to Mr. James, the manager.

Mr. MARTIN briefly responded, and said he hoped they would go away fired with the determination to establish new shipyards, the nearer Cardiff the better.

Leaving the Dowlais works the party went to the Bute Docks (see Plate XLVII.), where Mr. Hunter, the engineer, and Mr. J. J. P. Burt, the wharfinger (in the absence of Sir W. T. Lewis and Mr. Hurman), pointed out the interesting features of the docks, and the facilities that the company possessed for the despatch of steamers. It was stated that the company were able to ship coal on board of steamers as fast as they received it from the collieries, and the Lewis and Hunter patent tip was also shown at work. From the Bute Docks the party paid a visit to the Mount Stuart Dry Docks (see page 217), over which they were conducted by Mr. John Gunn, and from thence to the Bute Dry Docks (see page 218) and other noted establishments on the other side of the channel. After thoroughly inspecting the modern appliances of these works, a visit was paid to the premises of the Cardiff Channel Dry Docks and Pontoon Company, Limited. This company, which owns the pontoon on the east side of the Cardiff drain, is now building a large dry dock. The contract is in the hands of Messrs. S. Pearson & Sons, who, with the company, entertained the visitors to lunch. The dock was started in April last year by Messrs. Pearson, who have carried out so many important works in different parts of the world. The present company purchased the property of the old Dumfries Engineering Company, and with a capital of £125,000 set about providing the most modern accommodation for the numerous ships that passed through their hands. When completed, the new dock will take the largest cargo steamers afloat, and it was stated that the Government would have subsidised the undertaking only it was found that the entrance channel to Cardiff was not sufficiently deep. The length of the new dock will be 650 feet, with an entrance of 65 feet in breadth.

At a luncheon given by the company and the contractors, Mr. John Cory, of Messrs. Cory & Sons, presided, and he was supported by Mr. Henry Radcliffe and Mr. J. H. Cory (directors), and Mr. W. G. Blow (managing-director), Mr. J. B. Squire (general manager for Messrs. Pearson & Son), Mr. John Gunn (representing the Chamber of Commerce), Mr. W. R. Corfield (Chairman Shipowners' Association), Col. Guthrie (Shipbrokers' Association), and Messrs. T. Richardson, M.P., R. Thompson, H. Macoll, J. R. Fothergill, J. Gravell, J. F. Walliker, and J. Duckitt (representatives of the North-East Coast Institution).

After the loyal toasts had been submitted and duly honoured, the CHAIRMAN proposed "Success to the North-East Coast Institution of Engineers and Shipbuilders," and in doing so dwelt on the rapid

strides the town had made during recent years. When the large new dock now building by Lord Bute was finished, the port would have a dock accommodation of 150 acres. Their own dock, which was being constructed by Messrs. Pearson, would take in a ship 600 feet in length or four smaller vessels, and would add greatly to the facilities already possessed by the port.

Mr. T. RICHARDSON, M.P., in the course of a felicitous reply, said what they wanted was to tempt shipowners to buy more ships, and the only way they could achieve that was to tempt them with something they would be obliged to buy or be cut out in the markets of the world. They came to Cardiff expecting to learn something, and they had, he thought, ample opportunities of learning a great deal. The port from which he came (West Hartlepool) was a monopoly, owned by the North Eastern Railway Company. They put down docks that would suit the present time, thinking nothing of the future, and when that future came they refused to provide for the present. They in Cardiff provided for the future. They had been told when they had provided for the future that they had made fools of themselves for providing that which would never be wanted. They had, however, in a short space of time found that they were behind the times again. They had come to be instructed, and they were not disappointed, and whatever they might carry away with them, not the least pleasing part would be the hearty welcome which had been given them.

"The Company and its Contractors" was submitted in a few well-chosen remarks by Col. GUTHRIE, and Mr. H. RADCLIFFE and Mr. J. B. SQUIRES responded.

Mr. R. THOMPSON having proposed the "Chairman," Mr. JOHN CORY responded, and Mr. BLOW also responded to a toast of his health, which was submitted by Mr. CORFIELD.

The party then inspected the work which the contractors had in hand, and afterwards paid a visit to the Cardiff Exhibition.

SMOKING CONCERT.

In the evening the members were invited by the Bristol Channel Centre of the Institute of Marine Engineers to a reception and grand Smoking Concert, given in the Park Hall, Cardiff, where they were received by the President of the local branch of the Institute, Prof.

A. C. Elliott, D.Sc., and Lord Windsor, the Mayor of Cardiff. There was also present the chief representative men of Cardiff and the district, together with the officers of the naval, regular, and auxiliary forces.

Prof. A. C. Elliott, D.Sc., occupied the chair, and he was supported by Mr. Thomas Richardson, B.A., M.P., President North-East Coast Institution of Engineers and Shipbuilders; The Right Hon. Lord Windsor, Mayor of Cardiff; Mr. John Gunn, President Cardiff Chamber of Commerce; Mr. Charles A. Heywood, Chairman Reception Committee; Mr. W. R. Corfield, President Cardiff Incorporated Shipowners' Association; Mr. T. E. Watson, J.P., President Newport Chamber of Commerce; Dr. J. H. Treharne, J.P.; Mr. Ald. Trounce, J.P.; Mr. Lewis Williams, J.P.; Surgeon-Lieut.-Col. Healey, Major Threshie, and Capt. Reade, the Barracks, Cardiff; Mr. Robert Thompson, J.P., Past-President N.E.C.I.; Mr. J. R. Fothergill, Mr. J. F. Walliker, Mr. H. Macoll, and Mr. J. Gravell, Vice-Presidents N.E.C.I.; Mr. Morel, J.P.; Mr. Henry Heywood, J.P.; Mr. Councillor David, Mr. H. J. Simpson, Mr. Cory, J.P.; Mr. Ald. Carey, J.P.; Mr. David Gibson, Vice-President, B.C.C.; Messrs. J. Chellew, Robt. Davison, Jas. Ferrier, J. M'Callum, W. Simpson, and A. E. Smithson, Members of Committee; Mr. D. M'Callum, Representative to Council; Mr. Chas. L. Ryder, Hon. Treas. B.C.C.; Mr. George Sloggett, Hon. Sec. B.C.C.; Mr. A. Rickaby, Mr. J. Reavell, Col. Bingham, Sheffield; Mr. John Lockie, Editor *The Steamship;* Mr. H. H. Wake, Engineer Wear Commissioners; Mr. George Rutherford, Mr. T. W. Wailes, Mr. M. W. Aisbitt, Mr. J. Duckitt, Secretary N.E.C.I.; Mr. S. W. Allen, Mr. G. E. Macarthy; Mr. J. Nodder, Sheffield; Capt. T. H. Sloggett, Mr. Edward Lewis, Board of Trade; Lieut. W. H. D. Caple, Lieut. H. C. Newman, Mr. C. F. Gooch, J.P., Mr. A. K. Hamilton, Mr. J. G. G. Rule, Mr. F. R. Noton, Mr. A. F. H. Bancroft, Mr. C. Taylor, Mr. J. H. Riley, Mr. W. G. Reynolds, Mr. W. Sibun, Mr. H. Fownes, Mr. R. Hirst, Mr. W. Swinney, Mr. J. M. Campbell, Capt. W. Cassop, Mr. A. McGlashan, Mr. J. Barclay, Mr. J. Hogg, Mr. W. Evans, Councillors Waring, Andrews, Hughes, and Munn; Dr. T. Wallace, M.D., J.P.; Dr. Macormack, Major W. E. Jones, Major Rigg, Surgeon-Capt. Tatham Thompson, Col. E. C. Fry, Mr. Lewis Turnbull, Capt. C. E. Stallybrass, Lieut. A. E. Evans, R.N.R.; Capt. John Traill, Lieut. Hoyle, Capt. Rosser, Mr. John Spence, Tyneside Engine Works; Mr. Henry Radcliffe, Mr. Marcus Gunn, Mr. Charles Thompson, Sunderland; Mr. L. G. Laurie, Mr. John Boddy, Mr. Edgar, Capt. Parfitt, Newport; Mr. Mordey, Mr. Carney, Mr. Stevens, Mr. C. H. Bailey, Mr. Evans, Mr. J. B. Ferrier, Mr. Jackson, Mr. Scott, Mr. Symonds, Mr. Walker, and others.

The proceedings commenced with the "National Anthem" on the grand organ, which was joined in by all present.

The CHAIRMAN (Prof. A. C. Elliott, D.Sc.) said he rose to say a few words of welcome to the members of the North-East Coast Institution of Engineers and Shipbuilders, in the name of the nearly kindred society of the Institute of Marine Engineers. Their Institute had many habitations, and Cardiff claimed one of those habitations. They were, of course, anxious to extend the number of habitations; but they had never been able to found a centre in the North of England, because the ground was already occupied by the North-East Coast Institution of Engineers and Shipbuilders. He did not say that in any spirit of rivalry; all engineers were rivals—rivals in the art of doing well. Even the members of the society, if the society was any good, were rivals one with another. The North-East Coast Institution of Engineers and Shipbuilders had done a noble work. It had published proceedings that were of great and permanent value. Some institutions had surpluses—some had spent them in eating and drinking, and others had hoarded them; some, like the Institution of Mechanical Engineers, had nobly spent them in research for the benefit of the profession at large. But amongst those institutions the North-East Coast Institution had taken a distinct line; it had provided somewhat for the future—for the youths to whom the profession of the future was to be committed. It had founded the profession of engineering in the Durham University, and supported it to a great extent as well. They as engineers were happy and proud to welcome the Institution. They were happy to welcome them, because they knew that they (the visitors) were jolly good fellows, and they were proud to welcome them because they were proud of Cardiff. They knew that in Cardiff they could show them some things that must rejoice the heart of the mechanical engineer in whatever department he might have been trained, and in whatever department his life's business might be cast. Amongst other things, they were proud of their noble Mayor, and proud to witness his sympathy and deep interest in the commercial and industrial affairs of this great and rich country of South Wales. All honour to him, he said. Before he concluded, he must refer to the Past-President of the North-East Coast Institution: the name of Richardson was well known, and in Cardiff it did not require any introduction.

The MAYOR OF CARDIFF (Lord Windsor), in seconding the welcome of Prof. Elliott, said their Chairman had been kind enough to ask him to associate himself in the words of welcome that he had just addressed to

the members of the North-East Coast Institution of Engineers and Shipbuilders. He considered it a privilege to be allowed, on behalf of the Corporation and inhabitants of Cardiff, to add just two or three words of welcome. They prided themselves in Cardiff, at least, in throwing their heart into everything that they did: on that occasion they hoped they were throwing their heart into the welcome they were giving to the Institution. They were gratified that they should have selected Cardiff that year to inspect what they had to show them, and, he hoped, to instruct them (Cardiffians) a little bit too; and he sincerely trusted that they would pass a pleasant week, and that they would go away from South Wales and from Cardiff feeling that the people living there were anxious to make the best of their position, to make the best of their wealth and resources; but who felt that they could not do without the intelligence that might be brought into their midst from other parts of the country.

Mr. Thomas Richardson, B.A., M.P., in replying on behalf of the Institution to the welcome extended to its members, said it was very gratifying to him in coming to a town of such very great importance as Cardiff to hear on all hands with what conspicuous ability and energy their worthy Mayor fulfilled the duties that fell upon him. They were invited there that evening by the Bristol Channel Centre of the Institute of Marine Engineers—an institution which had a world-wide reputation second in importance to none in the country. Prof. Elliott in his remarks, he thought, paid the North-East Coast Institution a very high compliment. He said they did not possess a branch of their Institute on the North-East Coast because the ground was fully covered by their Institution. He thought they would all agree with him that such an important Institute as the Marine Engineers, if they had a meeting in the north, would find that they would possess a great many of their members there. Prof. Elliott remarked that such an Institute, composed of members who, as it were, were at different times on every part of the globe, found it difficult to have any local habitation; but he thought when they had their headquarters in London, and possessed such a large number of members, it was a sufficient index of the prosperity of that Institute. He was particularly pleased to be there that night, because he had some little time ago an invitation to one of their Bristol Channel Centre celebrations, which, unfortunately, he was unable to accept; but he had the pleasure of meeting Prof. Elliott only last week at the anniversary dinner of their Institute in London. Their chairman at that dinner had referred, in the course of his remarks,

to the fact that the engineers required some representation in the House of Commons. Well, they had had some representation there for a good many years; but he was pleased to think that at the present moment they had no less than fourteen representatives in the House of Commons who had, as it were, started life with the hammer and chisel. He thought that Prof. Elliott would bear him out that there was need of representation on behalf of the engineers in the House of Commons. One of the gallant admirals of our fleet, who was in the House, referred to the engineering members in the House of Commons, and said—he forgot exactly the remark he made, but it would bear this interpretation—that they placed too much importance upon that branch of the service in the navy. He thought anyone who was present at that dinner would be quite willing to echo that sentiment. The gallant admiral went on to say that what they wanted to recognise was that they were all one, and that they ought to think more of the word "we." Well, that was exactly what they thought, and as he said then, what they objected to was the "we" being retained with a big "W" for the executive, and a small "e" for the engineers. They wanted to see a capital "E" as well as a capital "W." He had no doubt in course of time they would bring the Admiralty Board to see that some greater recognition should be taken of the services of the engineers in the fleet. He could assure them all in the room that the invitation which they accepted to come there and the expectation of enjoyment that they formed had been very far exceeded. He had no doubt, in coming to a town like Cardiff, whose growth was one of the miracles of the age, that they would be heartily welcome. It was not a town that had suddenly risen into importance. If they went back into the pages of history they would always find that Cardiff was a town of importance. After again thanking the Bristol Channel Centre for their effusive welcome, the hon. member resumed his seat.

An admirable musical programme, under the able directorship of Mr. A. E. Smithson, was gone through. The organ solos, "Menuet Régence," by Bachmann, and "Andante in A," by Batiste, were well rendered by Mr. J. E. Deacon. The Caerphilly Male Voice Choir, under the conductorship of Mr. S. E. Evans, gave some excellent examples of Welsh chorus singing, and received well-merited praise. The song of Miss Beatrice Edwards, "For all Eternity," and its violin obligato, played by Mr. Lane Herbert, were greeted with tremendous applause. The subsequent efforts of Miss Edwards were equally appre-

ciated, as were those also of Miss Dot Prosser. The playing of Mr. Lane Herbert was very effective in his violin solos, "Cavatina" and "Tarentelli." Mr. J. F. Coughlin gave a capital clarionet solo. The inimitable Mr. Bert Lewis, who is so well known to Bristol Channel audiences, surpassed himself, if possible, on this occasion. "I ain't going to Tell" and other songs sung by him were all extremely entertaining to his audience. Inkey and Oakey, the humorists (Messrs. Thistlewrite and Williams), and Mr. Elliott, were all very clever in their various characters. "I'll sing the Songs of Araby" and "The Last Watch" were most charmingly rendered by Mr. E. T. Haddon. "The Skipper," sung by Mr. Morton Deane, and "The Outpost's Vigil," by Mr. S. R. Ham, both evoked much applause, and the duet, "Army and Navy," by Messrs. R. J. Williams and A. J. Parsons, was no less successful. Mr. Sam Allen, in his humorous representation of "Our Village Penny Readings," was exceeding good, and the audience insisted on his recall; Mr. Allen responded with a recitation. As an accompanist, Mr. F. Jones acted admirably. Mr. J. E. Deacon's organ and pianoforte selections were a very attractive and favourite part of the evening's entertainment.

A vote of thanks to the Chairman was proposed by Mr. J. R. Fothergill, to which Dr. Elliott replied. The very enjoyable evening terminated by the whole audience again singing, with the organ accompaniment, "God Save the Queen."

Thursday, June 25th, 1896.

A Special General Meeting of the Institution was held at Cardiff, on Thursday, June 25th, 1896, in the Lecture Theatre of the South Wales Institute of Engineers. Members were welcomed by Mr. Arthur Stevens, Newport, Monmouthshire, ex-President of the Institute. He expressed his regret at the absence of Mr. Henry W. Martin, of Dowlais, the President of the South Wales Institute of Engineers, who would have been present had not a very important engagement absolutely prevented him. He observed that they were very proud of the building in which they were assembled, and believed it could not be better employed than when it was being utilised by kindred societies like the North-East Coast Institution.

Mr. THOMAS RICHARDSON, M.P., who now took the chair, cordially acknowledged the welcome. He expressed the thanks of the members of the Institution to the South Wales Institute for having lent them that handsome hall for their meeting. It was a building of which the South Wales Institute might well be proud. He hoped their presence there would have the effect of making them ambitious of possessing a similar hall in the future, and of entertaining in it the South Wales Institute of Engineers when they should come north.

The business of the meeting was then proceeded with.

ELECTION OF MEMBERS.

The following new Members, Associates, and Graduate were unanimously elected :—

MEMBERS.

Brigham, Thomas, Engineer, Messrs. Brigham & Cowan, South Shields.
Gibson, David, Superintendent Engineer, 18, Wadsworth Avenue, Cardiff.
Gunn, John, Managing Director, Messrs. Mount Stuart Dry Docks Co., Cardiff.
Henderson, John, Naval Architect, 34, Burdett, Street, Liverpool.
Jobson, H. G., Marine Surveyor, Exchange Buildings, West Hartlepool.
Morch, C. J., Assistant Naval Architect, 20, Archbold Terrace, Newcastle-on-Tyne.
Roseti, G. S., Overseer N.A. Argentine Navy, 4, Radnor Place, Birkenhead.
Scott, William, Engineer, 134, King's Road, Cardiff.
Stephen, A. E., Engineer and Shipbuilder, Linthouse, Govan, Glasgow.

ASSOCIATES.

Caminos, T. L., Overseer, Argentine Navy, Grand Hotel, Newcastle-on-Tyne.
Cory, John, Shipowner, Cardiff.
Craik, A., Accountant, Messrs. Blyth Dry Dock Co., Limited, Blyth.
Frazer, Joseph, Merchant, Britannia Buildings, Cardiff.
Lodwidge, Philip, Accountant, Baltic Chambers, Sunderland.
Radcliffe, Daniel, Shipowner, Cardiff.
Radcliffe, Henry, Shipowner, Cardiff.
Wight, Robert M., Merchant, 42, The Exchange, Cardiff.

GRADUATE.

Lumley, William, Electrical Engineer, 38, Sidney Grove, Gateshead.

Mr. J. F. WALLIKER read a paper on "The Maintenance and Repairs of Marine Boilers" (see page 223). A discussion followed, to which Mr. Walliker replied, and the discussion was adjourned.

Mr. J. R. FOTHERGILL read a paper on "Marine Boilers, particularly in reference to Efficiency of Combustion and Higher Steam Pressures" (see page 235). A discussion followed, which, owing to the shortness of time at the disposal of the members, was adjourned.

The PRESIDENT proposed that the thanks of the Institution be extended to the following bodies for their cordial welcome and generous hospitality:—

The Mayor and Corporation of Cardiff.
The Mayor and Corporation of Newport.
The Cardiff Chamber of Commerce.
The Newport Chamber of Commerce.
The Newport Harbour Commissioners.
The Dowlais Iron and Steel Works Company.
The Alexandra Docks and Railway Company.
The Newport Reception Committee.
The President and Council of the South Wales Institute of Mining Engineers.
The Cardiff Channel Dry Docks and Engineering Company and Messrs. S. Pearson & Sons.
The Bute Docks Company.
The Bristol Channel Centre of the Institute of Marine Engineers.
The Great Western Railway Company.
The Rhymney Railway Company.
The Taff Vale Railway Company.
The Barry Graving Dock and Engineering Company.
The Cardiff Reception Committee.
The Barry Docks and Railway Company.

The proposition was enthusiastically received and carried by hearty acclamation, and the business of the meeting concluded.

At noon, the members were conveyed by a special train from the Taff Vale Station, Cardiff, to the Penarth Dock (see Plate XLVIII.), where Mr. T. H. Riches received them and conducted them to the dock-side, in the absence of the general manager, Mr. Beasley, who was engaged in London on Parliamentary business. The working of a patent tip, which owes its conception to Mr. T. H. Riches, was fully explained by that popular engineer. The party again joined the "special," which the Taff Vale Company had placed at their disposal, and a start was made for Barry *via* Penarth and Cadoxton. Arriving at Barry Dock Station, about 1·15, they proceeded to Culley's Hotel, where they were entertained by the directors of the Barry Graving Dock and Engineering Company to a magnificent luncheon, prepared in good style by Mrs. Brooks, the respected manageress for Messrs. R. P. Culley & Co.

The chair was occupied by Mr. T. R. Thompson, J.P., one of the directors of the Barry Graving Dock Company, and director of the Barry Dock and Railways Company, who was supported by Mr. Lewellen Wood, J.P., Col. Guthrie, J.P., and Mr. E. Bregeon (also directors of the former company), Mr. J. Lowdon, J.P. (general manager), Mr. J. D. Wood (secretary), Mr. D. Lowdon, M.I.M.E., M.I.N.A., Mr. J. H. Vincent (assistant manager, Barry Railway Company), Mr. D. W. Roberts (shipping superintendent), Capt. R. Davies (dock master), Mr. J. H. Hosgood (locomotive superintendent), Mr. C. A. Heywood, etc.

After the company had partaken of the generous hospitality of the Barry Graving Dock directors, a brief toast list was submitted, opening with the Royal toast, which was duly honoured.

The CHAIRMAN (Mr. T. R. Thompson), on rising to propose the toast of "Success to the North-East Coast Institution of Engineers and Shipbuilders," cordially welcomed the visitors on behalf of the directors of the Barry Graving Dock Company, and also announced that the Barry Railway Company desired to offer their hearty co-operation in the welcome thus extended. Knowing as they did that the members of the North-East Coast Institution of Engineers and Shipbuilders were gentlemen possessing a wide practical knowledge of all such subjects as engineering and other dock works, he (Mr. Thompson) did not think it was necessary to take up much time in expatiating upon the examples of such works as would come under their notice that day. The works at Barry would be their own showmen. Proceeding, Mr. Thompson said he was glad they had had an opportunity of inspecting other dock works in the Bristol Channel before coming to Barry, and invited them with confidence to compare with them the works which would be subject to their criticism that afternoon. He invited their especial attention to the graving dock of the Barry Graving Dock and Engineering Company (see page 221), constructed and equipped under the master-hand of his esteemed friend and colleague, Mr. John Lowdon, one of their own offspring, and a worthy offshoot of their own district. The length of the graving dock of the Barry Graving Dock Company is 760 feet; breadth, 113 feet; and depth, 26 feet at high-water spring tides; with a pumping power of 15,000 tons of water per hour. This graving dock had been pronounced by Lloyd's Committee to be one of the finest examples of graving docks in the United Kingdom, and Mr. Lowdon would have great pleasure in pointing out everything in connection with the works which would be of interest to them. The Barry

Railway Company also invited them to inspect their dock works (see Plate XLIX.), and particularly the low water entrance, by means of which vessels in ballast will be able to enter the Barry Docks at all states of tide, and loaded vessels will also largely share the same advantages. The existing dock, No. 1 of the Barry Company, has a water area of 73 acres, and an entrance basin of 7 acres. This dock has in it 24 tips for the shipment of coal, of which 3 are movable tips. The entrance to the basin, and the passage between the basin and dock No. 1 are each 80 feet wide, with 37 feet of water at high water of spring tides, and 29 feet at high water of neap tides, over the sills. The deep lock, which will shortly be opened, has a length of 647 feet, and a width of 65 feet, the depth of water over the sills being 53 feet at high water of spring tides, and 44 feet at high water of neap tides. At low water the available depth is 17 feet at spring tides, and 25 feet at neap tides. The dock No. 2, now in course of construction, will be opened in about eighteen months from the present time, with an area of 40 acres, and will contain 10 tips of the best and most rapid shipping character. This dock will be entered from dock No. 1, and will thus have all the advantages of the present entrance and also of the Lady Windsor Deep Lock. The average power per tip in shipping coal is 300,000 tons per annum. This does not represent the actual capacity of the tip, which is immensely in excess of 300,000 tons if kept constantly going, but it is a fair average after allowing for delays with the coal, delays with the ship for trimming, together with holidays and other drawbacks. As there are 24 tips in the original Barry Dock, this represents a tipping power of 7¼ million tons per annum at the existing dock. The greatest quantity of coal shipped at Barry has been 30,000 tons per day, 130,000 tons roughly per week, equal to 6,760,000 tons per annum; but these figures were attained without the aid of two new tips which have since come into use. The 10 tips in the new dock, to be opened in January, 1898, will be equal to shipping 3,000,000 tons at a moderate estimate. The present amount of coal shipped at Barry is about 5,000,000 tons per annum, and a vessel has proceeded to sea from the existing dock two hours after high water on an ordinary neap tide drawing 26 feet of water. This cannot be done at any other dock in the Bristol Channel. No vessels are beneaped at Barry for want of water, and it is now admitted by the highest authorities that docks, to be efficient and economical in working and of the greatest utility to shipping, must be constructed close to the deep water of the sea. The docks at Cardiff and Newport have served their day and generation. He was surprised to find that the obsolete system of constructing docks up

in the air, at a great distance from the deep water, and practically enclosed by extensive mud flats, was being perpetuated elsewhere at the present moment, but, of course, if the Barry Docks are, in the ordinary course, to have competition, the Barry Company naturally prefer that competition in docks should be in that form. Mr. Thompson concluded his highly interesting address, which was enthusiastically received at frequent stages, by submitting the toast of the visitors, which was received with much heartiness.

Mr. T. RICHARDSON, M.P., and Mr. ROBERT THOMPSON (Sunderland) suitably acknowledged the toast on behalf of the visitors; and having thanked the directors of both companies for the cordial welcome extended to them, and for the generous preparations made for their reception and entertainment, the latter gentleman said from what they had already seen of Barry he was of opinion it was destined to attain world-wide fame as a leading coal shipping port.

The toast of the health of the Chairman having been given, the company rose and proceeded towards the docks. Having assembled at the graving dock, the visitors and their friends were photographed, and afterwards proceeded to the graving dock works (see Plate XLIX. and page 221), which were inspected with a good deal of interest. In the dock was lying the s.s. "Indrani," of Liverpool, a boat carrying over 7,000 tons. Her length was so extensive that she could not be got into one-half of the dock. Capt. Trotter showed a number of the engineers over his boat, and the engine room, which is one of the finest in any cargo-carrying steamer, was generally admired. A cruise was then made round the dock in launches, after the hydraulic and other machinery had been inspected. The great water area and the admirable facilities for coal-shipping greatly impressed the visitors, and was highly appreciated by them. After inspecting other points of interest the party retrained and returned to Cardiff. Capt. Davies, the Barry dockmaster, showed the party round the dock with pardonable pride, whilst the officials did all in their power to make the tour interesting.

FRIDAY, JUNE 26TH, 1896.

An excursion to Ilfracombe on Friday, June 26th, on the invitation of the Cardiff Reception Committee, brought the interesting and enjoyable visit to a close.

The members and friends embarked in the saloon steamer "Cambria," leaving Cardiff at about 10 a.m., and arriving at Ilfracombe shortly after noon. A sumptuous luncheon was provided at the Ilfracombe Hotel, presided over by Mr. C. A. Heywood, the genial Chairman of the Reception Committee.

After lunch the CHAIRMAN proposed the toast "Success to the North-East Coast Institution of Engineers and Shipbuilders," which was responded to by Mr. ROBERT THOMPSON, Past-President, and Mr. JOHN DUCKITT, Secretary of the Institution. Mr. J. R. FOTHERGILL, Vice-President, proposed "The Reception Committee," which was responded to by Alderman TROUNCE and Mr. J. F. WALLIKER, Hon. Secretary of the Committee. The health of the Chairman was proposed by Mr. H. MACOLL. The CHAIRMAN briefly responded. This brought the toast list to a close, when the party dispersed to enjoy the beauties of Ilfracombe and its surrounding scenery.

At 4·30 p.m. the party embarked in the "Cambria" for the return journey, which was made to Penarth Pier, a distance of over 40 miles, in one hour and fifty-seven minutes. The weather was exceedingly fine, and every possible arrangement was made for the comfort and enjoyment of the members. Too much praise cannot be given to the members of the executive committees for the amount of forethought displayed in all the arrangements, and the kind and courteous way in which the members of the Institution were received by all.

DESCRIPTION OF WORKS, ETC.

NEWPORT.

The Alexandra Docks (see Plate XLVI.).

A remarkable feature in connection with the Alexandra Docks is their fine natural position, being within convenient access to the large collieries of East and West Monmouthshire by means of the Great Western Railway system with its numerous branches; there being, too, direct communication *via* the Pontypridd, Caerphilly, and Newport Railway with the Rhondda Valley collieries. The London and North Western, the Midland, and also the Brecon and Merthyr systems are likewise connected with these docks. Shipowners agree as to the excellency of the approaches to the docks, and, as pointing to the care and supervision exercised, the docking and undocking of ships, by night and day, has been carried on without damage to property since opening.

The water surface of the North Dock is 28¾ acres, with a large graving dock of 515 feet leading therefrom. The lock is lit with electric lights, and is 350 feet long by 65 feet broad; average depth—neap tides, 25 feet; spring tides, 35 feet. The facilities provided at these docks may, in a word, be said to be unequalled in any port in the kingdom. Coal is shipped much more rapidly than at any other port in the Bristol Channel, and as an instance of quick despatch, it may be mentioned that a vessel of some 12,000 tons burthen was docked, berthed, loaded, and cleared in some fifty hours. The facilities for bunkering are also far in advance of other ports, for it matters not in what part of the dock a vessel is lying, her bunkering can be proceeded with.

The South Dock, which cost £500,000, was constructed under the Dock Act of 1882 by the Dock Company, from the designs of Mr. W. Stopford Smyth, M.I.C.E., and is 1,500 feet long, having a width of deep water of 550 feet. The entrance lock from the river Usk to the South Dock or Extension is 503½ feet between the outer and inner gates, divided by intermediate gates into lengths of 370 feet and 133½ feet. The width of the lock is 72 feet. Surrounding the South Dock are nearly 200 acres of land for sidings and storage, and it has a frontage to the river Usk of a mile and a quarter. There are besides 100 acres of land reserved for depositing ballast. The total present area of water, including the North and South Docks and the Timber Pond, exceeds 60 acres; the further extension of the South Dock will add 10 acres of

water area. The total area of land surrounding the docks is 400 acres; the land reserved for depositing ballast, 193 acres in addition; the total frontage to the river Usk, $1\frac{2}{3}$ miles; and the railway sidings will ultimately extend to 50 miles in length.

The Old Dock.

The Old Dock, the jubilee of which occurred on October 10th, 1892, also offers excellent facilities for the loading and unloading of all descriptions of goods. It is capable of receiving steamers of the greatest capacity, some of the largest ships which ever entered the Bristol Channel having discharged cargoes here.

Tyne Engine Works.

Mr. C. H. Bailey, the proprietor of these works, carries on a large business in dry-docking and general ship-repairing work. The premises are large and commodious, and in every way adapted for carrying out every description of work with the utmost despatch. Placed on either side of the shop are two powerful cranes, running the entire length of the works, capable of lifting up to 10 tons. Mr. Bailey shows his enterprise in laying down a large 35 ton lathe—length of centres, 30 feet; height of centres, 3 feet 7 inches. He also has patent hydraulic jacks of 300 tons for raising collapsed boiler furnaces. Mr. Bailey has also a branch of the Tyne Engine Works at Barry Dock, where his premises are quite as extensive as they are here, and the amount of business carried on there is quite as large as at Newport.

Messrs. L. G. Laurie & Co.'s Works.

These works are well situated in Mill Parade, and are fitted out for all classes of engineering, having the best facilities and the most useful kind of machinery for repairing all parts of marine engines and boilers; also machinery for repairs to ships' hulls, such as large rolls, punching and shearing machines, and large furnace slabs and other tools. Messrs. Laurie have also a shop for carpenters and shipwrights fitted out with saw, bench, etc. Also a shop fitted up with best facilities for plumbers', coppersmiths', and tinmen's work.

Messrs. Mordey, Carney, & Co.

Situated at one of the most convenient and accessible parts of the western bank of the Usk are the foundries, forges, fitting shops, boiler makers' yards, copper smiths, carpenters' shops, shipbuilding slips, etc.,

of Messrs. Mordey, Carney, & Co. Under the control of this firm are three graving docks in convenient proximity to each other: the Edith, 220 feet long; the Alice, 289 feet long; and the Mary, 350 feet long; besides which there is the repairing berth in Jack's Pill close by 350 feet long. The last-named berth is of the utmost service to the firm, is easy of access and highly convenient, especially for survey jobs, as steamers may be free of charge until all internal repairs are completed before entering one of the dry docks. The Mary Dock cost about £30,000, and its dimensions enable the firm to take some of the largest vessels. The width is 30 feet, and the depth 32 feet, whilst the bottom is concreted throughout. Four additional feet of water on the cill is another important feature, which makes the accommodation wellnigh complete.

Newport Corporation Electricity Works.

One of the most interesting places visited was the Newport New Electrical Lighting Supply Works. These works were opened on the 14th October, 1895, by the then Mayor of Newport, Ald. J. C. Sanders. The site of the works has been well chosen, affording ready access to coal and water, and is in direct communication with the Great Western Railway. These works have been laid out on the most approved plan. In the boiler-house there are four Lancashire boilers, each 28 feet long by 7 feet 6 inches diameter, with flues 3 feet diameter, giving a grate surface of 36 feet. The working pressure is 125 lbs., but they can be worked up to a pressure of 150 lbs. per square inch, and each boiler is capable of evaporating 4,500 lbs. of water per hour, with a feed supply temperature of 60 degs. Fahr. Each boiler is fitted with Proctor's mechanical stokers, driven by a small horizontal engine, and with Meldrum's system of forced draught being arranged when the boilers are required to work with natural draught. These boilers are fed with three duplex feed pumps, each capable of delivering 1,500 gallons of water per hour at a piston speed of 50 feet per minute. Three Berryman feed-water heaters are erected. When the engines are working non-condensing these heaters maintain the water supply to the boilers at a temperature of 200 degs. Fahr. The boiler house plant includes one of Worthington's self-acting jet condensers, which maintains a constant vacuum of 27 inches, and is capable of condensing the exhaust steam of 750 I.H.P. The condenser has two high-pressure cylinders and two double-acting injection water plungers.

In the engine house, which is 93 feet long by 50 feet wide, are four engines of the horizontal compound condensing type of the following dimensions:—

High pressure cylinder	13 inches diameter.
Low pressure cylinder	24 inches diameter.
Length of stroke	24 inches.
Speed	110 revolutions per minute.

And are arranged for working in conjunction with the separate condenser, and each engine is capable of giving off a continuous load of 150 I.H.P.

The fly-wheels are 12 feet diameter, each weighing over 8 tons, and grooved for eight cotton ropes of $1\frac{1}{4}$ inches diameter.

Coupled direct to the engines are four Hall patent high tension alternators, each giving an output of 75 kilowatts, and capable of supplying current to 2,500 lamps of eight candle power.

The speed at which the alternators are run is 525 revolutions per minute, and the mean speed at which the armature conductor is passed by the field magnets is about 7,000 per minute. The approximate weight of each alternator and exciter, with rails and bed-plates, is 12 tons.

The switchboard is fixed at one end of the engine house, and is fitted with a complete set of instruments for controlling the current and regulating its distribution between the several currents; it is designed to maintain high installation. In the test-room are a full set of instruments necessary for the complete equipment of the testing department.

The day load plant is placed in a separate building at the south east corner of the premises. This consists of a semi-portable under-type combined engine and boiler of 50 I.H.P. The working pressure is 140 lbs. per square inch, and the speed of the engine is 135 revolutions per minute. The electric current is generated by Hall's combined alternator and exciter fixed on one bed-plate of similar construction to the large alternators. For this a separate switchboard with all the necessary instruments is provided, which is connected to the main switchboard and is arranged so that the dynamo can be controlled at either board.

Newport Engineering and Ship-repairing Company, Limited.

The works of the Newport Engineering and Ship-repairing Company, Limited, are in Alexandra Road, conveniently situated for carrying out the repairs of vessels in either the Alexandra or Old Dock or in the river. As the name implies, the company principally lay themselves out for shipping, but they also do a considerable amount of work in connection with various collieries and works in the neighbourhood. The shops are laid out with every modern convenience, and are well adapted to carry out work with the greatest possible despatch. Many large damage repairs have been executed by this company in the Alexandra Graving Dock.

The Newport Ropery Works,

in Clarence Place, are most conveniently situated either for despatching by rail or water, and are devoted to the manufacture of every description of white and tarred hemp, Manilla and coir ropes, trawl warps, bolt ropes, spun-yarns, lines, and twines of every description. The works, which are in every respect well adapted to the trade engaged in, have been fitted up with machinery of the newest and most approved character, and by the assistance of this valuable introduction the firm are enabled to produce goods of the most standard quality. The machinery is driven by 150 horse-power steam engine, and the works have just turned out two gigantic coir ropes, measuring 22 and 23 inches, and weighing nearly ·3 tons each. Mr. Charles D. Phillips is the sole proprietor, to whom credit is due for his successful efforts in rapidly creating a valuable and substantial business connection for the disposal of the productions. The premises in Clarence Place have been specially enlarged for developing the business, and are therefore well adapted for its requirements.

Messrs. Richards & Hopkins.

Messrs. Richards & Hopkins, engineers, iron and brass founders, Britannia Works, Pillgwenlly, have works which cover an acre of ground, and are being extended from time to time as the growth of the business necessitates. One of the most notable additions of recent years has been the construction of a fine erecting shed, in which the machinery made by the firm is put together. The firm possess a brass foundry capable of casting 2 tons of metal at a time, and in the large ship-repairing shop there is an excellent plant, comprising heavy punching and shearing machines, and powerful rolls for plate bending. There is a railway siding for the main line and the docks, affording ample facilities of transport. All the machinery in turning sheds, smiths' shops, etc., is of the best modern type, and the fine lathes, slotting machines, punching and drilling machines, etc., are all driven by compound condensing engines.

South Wales Brattice Cloth and Indiarubber Company.

The South Wales Brattice Cloth and Indiarubber Company, Limited, have their works and wholesale warehouses at East Usk Road, the same having been rebuilt and rearranged within the last couple of years on the most modern and approved lines. The plant and machinery are of the most efficient kind, and in the manufacture of brattice cloth, air tubing, tarpaulin, rick cloths, railway truck covers, and horse cloths, the company are doing a very large and increasing business. In addition to

being manufacturers, the company do an extensive trade as merchants in indiarubber for all mechanical purposes, valves, sheets, washers, engine packing, asbestos goods, etc. It is satisfactory to note that Newport is not behind the times in this or in other branches of manufacture.

Union Dry Docks Company, Limited.

The Union Dry Docks Company have their head office at Brithdir Works, Alexandra Docks, with branches at Sharpness and Barry. Their present dry dock at Newport is of modern construction. It is 350 feet long, 58 feet wide at the gates, and has a depth at spring tides of 27 feet. The work at the new dock is well in hand, and, when completed, the dock will be one of the largest in the Bristol Channel, affording accommodation which cannot at present be provided at Cardiff or Barry Docks. Its width will be 65 feet at the gates, depth 35 feet, and it will take in a steamer of 530 feet over all. The works are situated near the Alexandra Docks, forming a completely equipped establishment in themselves, and were laid out for working on vessels in the Alexandra Docks and that side of the river generally. The repairing establishments at Sharpness and Barry Docks cover every kind of work in iron and wood shipbuilding, boiler-making, hull and engine repairing. The new dock will be fitted with centrifugal pumps capable of pumping the dock dry in one hour, so that a steamer can enter and dry dock for examination, undock, and be at her loading berth on the same tide.

CARDIFF.

Dowlais Iron and Steel Works.

These works were formally opened in February, 1891.

The blast furnaces, four in number, are each 75 feet high from the hearth level, and 85 feet high from the works' rail level, 20 feet diameter in the boshes and 10 feet in the hearth, with eight tuyeres and an elaborate system of water-cooled boxes, built into the boshes, and surrounding the lower part of the hearth.

The furnaces have closed tops, with cup and cone chargers; the gas, taken off by downcomers, passes through a main parallel to the line of furnaces with connections for the stoves, then into a smaller main by which the gases are led to the boilers.

Inserted in the horse-shoe main of each blast furnace is a Le Chatelier's thermo junction, which can be joined up with a self-recording

apparatus, by means of which a record of the temperature of the hot blast supplied to each furnace, and also the times at which the stoves have been changed, is obtained. An instrument also automatically records the time and interval at which the blast furnaces are charged.

The blast for the furnace is heated by eleven Cowper stoves, each 68 feet high and 24 feet diameter, with a heating surface of 47,500 square feet, giving an average temperature of 1,300 degs. Fahr.

At the back of the furnaces, and in a line with them, are three coke-bunkers, each having a capacity of 1,250 tons; twelve ore bunkers, each having a capacity of 867 tons; four limestone bunkers, each having a capacity of 850 tons. The ore and limestone bunkers may be used at any time for calcining purposes.

The bunkers are filled from wagons running over a railway upon a gantry carried by iron columns passing over their tops. The wagons are raised by a hoist. This hoist, as well as the furnace hoist, is water-balanced, the former having a lift of 58 feet, while the latter has a lift of 85 feet.

The engines for supplying air and water to the furnaces and lifts are contained in a large engine house 146 feet long, 32 feet wide, and 60 feet high, with water tanks on the top of 178,000 gallons capacity for the tuyeres, and 90,000 gallons for the hydraulic engines, and bottom tanks with a capacity of 120,000 gallons.

Three blast engines were supplied by Messrs. Kitson & Co., and are of the compound surface condensing type, direct-acting with the blast cylinders below the steam cylinders. The high pressure cylinders are 36 inches diameter, the low pressure cylinders 62 inches diameter, the blast cylinders, 88 inches diameter, and all the cylinders are 60 inches stroke, fitted with piston valves. The fourth blast engine is by Messrs. D. Adamson, and is also of the compound surface condensing type, but with an independent condenser. The high pressure cylinder is 36 inches diameter, the low pressure cylinder is 64 inches diameter, the blast pressure cylinder is 88 inches diameter, and all the cylinders are 60 inches stroke. The high pressure cylinder is fitted with Wheellock valve gear, and the low pressure cylinder with the ordinary piston valves. Each engine is capable of developing 1,200 horse-power, and delivering 25,000 cubic feet of air per minute, at a pressure of 4½ to 10 lbs. per square inch.

The pumping machinery includes two compound pumping engines for the furnace and mineral hoists, each having a capacity of 1,500 gallons per minute; six compound pumping engines for tuyere and

cooler water, each having a capacity of 400 gallons per minute; two compound boiler feed pumps, each capable of delivering 100 gallons per minute at the full boiler pressure. The steel boilers, twelve in number, are of the ordinary double-flued Lancashire pattern, 8 feet 6 inches diameter and 30 feet long, work at 100 lbs. pressure, and are gas fired. The boiler chimney is 240 feet high, with an inside diameter of 13 feet 6 inches at the top.

The hydraulic and electric light houses contain one double tandem compound hydraulic pumping engine, delivering 160 gallons per minute; two compound hydraulic pumping engines, each delivering 100 gallons per minute, and one compound hydraulic pumping engine, delivering 90 gallons per minute. There are also two single tandem compound engines, with Proel valve gear, each indicating 80 horse-power, and developing at the dynamo 230 ampères at 230 volts. All the hydraulic pumping engines work at a pressure of 750 lbs. per square inch, and there is an independent surface condensing plant for the hydraulic and electric light engines.

The weekly output per furnace is, with moderate driving, about 1,300 tons. The pig-beds are large. The pig-iron is allowed to become cold on the beds, and its removal and breaking up is accomplished by mechanical means. The apparatus consists of quick-running overhead steam-travelling cranes, which sweep the whole surface of the pig-beds, and bring the iron to the hydraulic breaker, where it is broken and loaded direct into wagons. Two hydraulic "pig-breakers" are in use, and can readily deal with the output of the furnaces.

The slag from the blast furnaces is removed in ladles mounted on carriages, which tip it sideways while in a molten state wherever it is required. By means of a subway there is an independent railway connection from the works to the wharf on the Roath Dock, on which stand six hydraulic wharf cranes, each capable of lifting 35 to 40 cwt. These are supplied with hydraulic power from the works, and are used for loading and unloading all the materials for the Cardiff and Dowlais Works.

The Steel Works.

The plant for the production of mild steel consists of six 30 ton Siemens smelting furnaces, each furnace having its own chimney. To assist in charging the materials into these furnaces a 30 ton electrically-driven overhead crane is placed above the charging platform. In front of the smelting furnaces are two sets of vertical heating furnaces for ingots, each having ten holes and fitted with Siemens regenerators and valves.

The furnaces are heated by gas supplied by eighteen Ingham producers, charged by mechanical stokers.

The ingots, when cast, weighing about 6 tons each, are removed from the casting pit by a steam crane and lowered into the vertical ingot-heating furnaces. Another steam crane raises the ingot from the heating furnaces and places it on a hydraulic tilter, which lowers it on to the rollers of the slabbing mill, where it is reduced to a slab of the desired thickness and width. The rolls of this mill are 36 inch centres, and can edge slabs 3 feet 6 inches wide. The slabbing engines' cylinders are 48 inches diameter, 60 inches stroke, and geared two to one. The slab passes from the slabbing mill to the slab shear, where it is cut to the necessary sizes by a shear capable of cutting a slab 3 feet 6 inches wide and 10 inches thick; these are removed to a re-heating furnace by a circular charger, which can draw and charge slabs up to 6 tons weight, and is placed so as to take the slabs from the slabbing mill and charge them into the re-heating furnaces, then to take them from these furnaces and place them on the rollers of the plate mill, where they are rolled into a plate. The plate mill rolls are 32 inches diameter and 9 feet long, and the engines driving them have cylinders 54 inches and 60 inches stroke, and are geared two to one. The plates are cut up by heavy plate shears into various sizes, according to specifications received by the firm. Every plate is tested for tensile strain and bending.

The ten Lancashire boilers in use for generating steam for the machinery in the steel works are of the same dimensions and type as those described under the blast furnace plant.

The Mount Stuart Shipbuilding, Graving Docks, and Engineering Company, Limited.

The graving docks (two in number) and shipbuilding premises of this company are close to the entrance of the Bute loading docks, and are on an extensive scale. The graving docks can accommodate vessels up to 10,000 tons deadweight, and ships do not incur Cardiff or Penarth dock dues through using them. No. 1 graving dock is 440 feet long and 70 feet wide. No. 2 dock is 420 feet long and 105 feet wide, with blocks laid for two vessels to be berthed alongside each other. Inner gates are provided, which retain water to a depth of 20 feet (on blocks) when required. The machinery and plant are of the newest description, designed to execute work with the utmost despatch and economy. Special attention is given to orders for salving wrecked or stranded

vessels. Centrifugal pumps and salvage gear can be shipped at a moment's notice. The workshops are fitted with locomotive cranes, having a lifting power exceeding 40 tons. These docks and works are carried on under the management of Mr. Thomas W. Wailes; John Gunn, Esq., J.P., is chairman of the company.

The Bute Shipbuilding, Engineering, and Dry Docks Company, Limited, Cardiff.

The above works and dry docks are situated just within the main entrance to the port, viz., Roath Basin, and hold exceptional advantages to carry out their business. The docks are 600 feet long and 74 feet wide at bottom. Vessels can be docked and undocked regardless of tides and without the aid of tugs, and are then in a position to proceed to either the Roath Basin, Roath Dock, or East Dock, for loading with the minimum of transporting. The dry docks are so constructed that the water can either be pumped out or run away into the Channel. The whole of the machinery is of the most modern type, thus enabling the company to carry out repairs with economy and despatch.

Junction Dry Dock, Cardiff.

The Cardiff Junction Dry Dock and Engineering Company, Limited, carry on business at Cardiff and Barry Docks as dry dock owners, ship repairers, and engineers. They have a large dry dock conveniently situated between the East Bute Basin and West Bute Dock, with every possible convenience for all kinds of repairs. A large foundry at their Tubal Cain Works at the top of the East Bute Dock, where they make a speciality of castings for ships, particularly propellers, and also do every description of castings. They have also a ship-repairing works adjacent to the Commercial Dry Dock, opening out of the Roath Dock Basin. This firm has also a thoroughly equipped ship-repairing works at Barry Docks. The works are under the management of Mr. E. Jordan, who has been with the company since its formation in 1881.

The Tydvil Engineering and Ship-repairing Company, Limited.

A very large and thoroughly representative engineering and ship-repairing business is carried on by the above-named company, which commenced operations on May 2nd, 1891, and has since had a highly successful career. These works, which are admirably situated at a

point between East and Roath Docks, and adjoining the Commercial Dry Docks, are extensive, but are at the same time very compact in their arrangement, and are organised throughout in a manner conducive to the greatest convenience in the execution of work. Iron and brass foundries, boiler sheds, coppersmiths' and shipwrights' shops, and general engineering shops are included in this establishment, all these departments being fully equipped with the newest and best machinery for their several purposes. These works are carried on under the careful supervision of the manager, Mr. W. Scott.

The Mercantile Pontoon Company, Limited.

The works of the Mercantile Pontoon Company, Limited, are centrally situated on the Bute Docks system, close to the Roath Basin and the entrance locks of the East and Roath Docks.

The works appear to be a duplicate of the North-East Coast style of architecture for engineering shops, and are well laid out for dealing with engine ship-repairing work. The pontoon adjoins the works, and lies afloat in the Roath Dock.

The pontoon, which is 350 feet long by 70 feet broad, and has a lifting power of 3,500 over and above its own weight, has been a striking financial and mechanical success, embodies several unique ideas, and is self-docking. The advantages of a pontoon for painting ships is here very strikingly illustrated, as the amount of light and air obtained dries the hulls of vessels very rapidly.

Mr. R. A. Foster is chairman of the company, Mr. George Rutherford, managing director, and Mr. F. Morris, manager and secretary.

The Tyneside Engine Works, Limited.

The works of this company occupy a very favourable central position, immediately adjoining the Commercial Dry Dock, and comprise extensive fitting, machine, and erecting shops, coppersmiths', plumbing, shipwrights', joiners', pattern makers', blacksmiths', and boiler shops, with good cranage equipment, and an ample supply of high class machinery for general ship repairing, new engine and boiler building, etc.

Hill's Dry Docks and Engineering Company, Limited, Cardiff.

Hill's Dry Docks and Engineering Company, Limited, are the lessees of three graving docks, all of them being within the Bute Docks, and thus possessing the advantage of being independent of tides and accessible to

vessels at any hour of the day or night, a matter of no small importance in the graving dock business. Of these docks two open out of the west side of the East Bute Docks, the one being 408 feet, and the other 400 feet long, and both having a width of 48 feet at the entrance, with a depth of water on the blocks of 17 feet, and the third is situate at the top of the West Dock, its length being 232 feet by 40 feet in width at the entrance, with 12 feet depth of water of blocks. All these docks are in direct communication by means of a telephone with the company's office at the Exchange. The company also lease an extensive piece of ground alongside their graving docks, on which they have erected a fine range of buildings for their engineering department, consisting of a fitting shop and foundry, furnished throughout with all the latest improved machinery and appliances, there thus being on the spot every facility for making castings in iron and brass for any kind of engineering work, and for carrying out every description of repairs that may be required, whether in iron, wood, or machinery. A siding running directly along the range of the works connects them with the main system of the Great Western Railway, rendering the transport of material and finished goods to and from the works a matter of the greatest ease. These works are under the management of Mr. Thomas Campbell.

The Penarth Shipbuilding and Ship-repairing Company, Limited, Penarth Dock.

The Penarth Shipbuilding and Ship-repairing Company, Limited, which was founded by an influential body of gentlemen of the town and locality in 1878, has its works alongside Penarth Dock, and thus has splendid facilities for carrying on repairs to vessels while they are either taking in or unloading cargo—a great saving to owners, both in time and expense, being thereby ensured. The works comprise a slipway 867 feet long, capable of taking up vessels of 300 feet in length and 2,400 tons gross register; a gridiron 374 feet long, capable of accommodating vessels of 1,000 tons gross register; and an extensive series of workshops, fitted throughout with electric light, and complete with all the most modern and best type of machinery for shipbuilding, marine engineering, marine boilermaking, and every class of repairing work likely to be required for either steam or sailing vessels. Alongside the slipway is erected a powerful radial crane, capable of transferring ships' propellers, shafts, winches, or other heavy material, direct from a railway truck, or from the fitting shop door, on to a vessel's deck, or into the engine room

or holds, at one lift, or *vice versa*. The company has devoted much attention to the development of the shipbuilding department of its business, having built and engined in all twelve new steamers at these works since their establishment.

The Barry Graving Dock and Engineering Company (see Plate XLIX.).

This company's graving dock is situated near the north-east corner of the Barry Dock, and in close proximity to the Barry Dock Railway Station. It is 725 feet in length by 113 feet 6 inches in width, with a width of entrance of 60 feet, and has a depth of water on the sill of 24 feet. About midway it is divided by a caisson, and has a double line of blocks for its full length, and, excepting when the dock is occupied by a vessel of enormous length, four vessels, or even more, according to size, may be accommodated at the same time; while, when occasion serves, it can, by combining the two divisions of the dock, handle a ship of 725 feet in length. The dock is built of Sully stone, with granite altars and coping. Railway tracks, in direct communication with the Barry Company's lines, run completely round the graving dock, with sidings to the engineering works. Travelling cranes are fitted upon the rails, capable of lifting weights up to 12 tons.

A row of lofty and commodious shops, abundantly supplied with light and air, run parallel with the south wall, and have a frontage of 525 feet. These have been erected from the designs of Mr. Lowdon, the company's general manager, who has also superintended the whole outfitting of the shops with the most complete modern machinery.

On the west end of the terrace of buildings is the shipbuilders' and boilermakers' shop; this is 153 feet long, by the greatest width of 71 feet. It is fitted up with the most modern tools and appliances. Next comes the copper and tinsmiths' and plumbers' shop, then the pump engine and boiler house, the engines of which are of 510 horse-power. They are coupled direct to two 40 inch centrifugal pumps, which may be used separately if required, and which are guaranteed to empty both divisions of the dock—that is, more than 60,000 tons of water—in a little over four hours. The boilers, three in number, were made by Messrs. Galloway, of Manchester, for a working pressure of 100 pounds to the square inch. To the eastward is situated the building devoted to general stores and tools. Its position in the centre of the block is convenient, being accessible from all parts of the works. The machine and fitting

shop has been completely and skilfully fitted up and arranged for its purposes. Among the machines may be mentioned the powerful screw-driven slotter of Messrs. Buckton & Co., the double-headed shaping machine of Messrs. Hulse, the patent planing machine of Messrs. Dean, Smith, & Grace, and a 50 inch lathe of Messrs. Butterfield, weighing about 50 tons. Overhead travelling cranes run from end to end of this engineering shop.

The machinery is driven by three Otto gas engines, representing a combined power of eighty-five horses. To the foundry two of Stewart's patent cupolas are fitted up, also drying stoves and brass-melting furnaces. The smiths' shop is completely fitted up with forges and steam hammers, and occupies the eastern end of the block of buildings. This shop is so constructed as to be able to deal with the repairs of the largest forgings. Behind the fitting shop is a saw mill, a commodious separate building for the pattern makers and joiners, a large boat building shed, etc. The company manufacture their own gas for supplying the Otto engines by the use of Dowson's plant. The shops are for the most part constructed of wrought iron, whereby strength, light, and fireproof qualities are combined. There is also a complete electrical plant for lighting, and for driving the wood-working machinery. The company are about to build a second single graving dock of sufficient size to take in the largest merchant steamers afloat.

NOTES ON THE MAINTENANCE AND REPAIRS OF MARINE BOILERS.

By J. F. WALLIKER.

[Read before the Institution, at Cardiff, on June 25th, 1896.]

One of the principal points to be considered in the paying life of a steamer is the boiler question, as care exercised in ordinary upkeep from the first becomes a marked factor when increase of years and adoption of newer types of vessels brings down to almost the vanishing point the necessary margin of profit which tempts the capitalist.

It may be specially interesting to note in this respect that on December 31st, 1895, the total number of steamers registered in Cardiff alone numbered 290, with a total of 183,900 registered tons.

In bringing forward for the consideration of the members a few points for discussion, founded principally on the writer's experience, it will not perhaps be necessary to say that the subject-matter is confined entirely to the present cylindrical type (or Scotch boiler) as, it is understood, with few exceptions, this is in universal use. Whether the future boiler of the mercantile marine is or is not to be of the water-tube pattern does not appear to be in any way settled, but it is certain that many more boilers of the present type will be built, and that the evolution of the new boiler will be a slow one. That the water-tube boiler is highly successful for certain classes of vessels is an undoubted fact, and one of the principal objections made to its adoption has been for some time done away with, in the universal use in the best and most modern cargo boats, of apparatus for supplying fresh water for auxiliary use. The working pressures of marine boilers is gradually getting higher and higher, and, as we appear to have nearly reached the limit of thickness in the flat plates of the present boiler, some modification in form will be necessary.

The increase of pressures will be easily seen from the subjoined table corrected up to the middle of last year :—

TABLE SHOWING INCREASE OF PRESSURES IN MAIN BOILERS OF VESSELS CLASSED IN LLOYD'S REGISTER IN 1885 AND 1895.

Boiler Pressure.	No. of Vessels. 1885.	No. of Vessels. 1895.
Below 60 lbs.	122	40
60 lbs. to 70 lbs.	673	217
70 lbs. to 80 lbs.	1,326	666
80 lbs. to 90 lbs.	1,650	1,101
90 lbs. to 100 lbs.	346	397
100 lbs. to 110 lbs.	102	321
110 lbs. to 150 lbs.	33	213
150 lbs. to 160 lbs.	34	517
160 lbs.	14	2,200
Above 160 lbs.	3	416

Before passing to the main question of maintenance and repairs, there appears to be two factors which have intimate relations with them, and which must assist or retard the ultimate success of the most careful and elaborate supervision, and these are *design* and *manufacture*.

DESIGN.

Marine boilers are unfortunately often designed and placed in a vessel without due regard being paid to accessibility both of the exterior and interior parts, and that this is a crucial matter is too often shown after a long course of *necessary* neglect by the extensive repairs and renewals that are required. The writer would then place accessibility in the forefront of all boiler design; the heating and grate surface being allowed for, the boiler should be so made (and it can be made) that all its parts can be got at for cleaning and examination. What is usually seen in ill-designed boilers? Tubes and stays brought close to the furnace crowns and shell of boilers, stays placed in waterways, at the sides of mud-hole doors, etc.

Wide spacing of stays at the combustion chamber back seems to be a point often omitted when designing a boiler, and there appears to be no reason why a limit of $\frac{9}{16}$ or $\frac{5}{8}$ inch should be imposed on a flat plate at this part when a $\frac{3}{4}$ inch one is in successful use in an equally hot or hotter part, viz., the furnace. The difference in the staying of this part with a $\frac{9}{16}$ inch and a $\frac{3}{4}$ inch plate can be easily seen from the accompanying sketch (Plate XL. and XLI.), which shows a marked difference in favour of the thicker plate; actually, 264 stays with a $\frac{9}{16}$ inch plate and 156 stays with a $\frac{3}{4}$ inch plate.

MANUFACTURE.

A very few words as to manufacture. The workmanship in the marine boiler has reached such a high state of general excellence that nothing but praise can be meted out when adverting to it. The use of plates of over 1⅝ inches in thickness and of a weight of some tons necessitates the nicest adjustment of parts in the workshop, and, indeed, boilermaking has almost become one of the fine arts in shop manipulation. The use of the hydraulic riveter and closer has done everything in this branch, and it is to their universal adoption that the high pressure boiler of the present day is a possibility and a success.

MANAGEMENT.

The superiority of the system upon which boilers of the present day are worked compared with that of fifteen or twenty years ago show enormous strides in the general condition in which they are found; at that time twelve years was usually looked upon as a good life for a marine boiler, and with the lighter scantlings, indifferent workmanship, and general want of knowledge in treatment this remark was more or less perfectly true. With, however, the present better knowledge it is not a bold assertion to make that thirty years will not be an excessive age, and more especially when it is remembered how many boilers of over eighteen years of age of the older type, and under the newer conditions of knowledge, are still in existence, and doing good work.

The chief items in internal deterioration are :—

1. Pitting and corrosion ;
2. Overheating of plates due to scale, etc. ; and consequent
3. Wasting ; and
4. Distortion.

The chief factors in external deterioration are :—

1. Leaking at landing edges and rivets.

Application of Zinc and Soda.—The cause of pitting and corrosion has been discussed almost *ad nauseam* in every society taking an interest in boiler deterioration, but it is now a matter of universal knowledge that its harmful effects can be entirely obviated by cleanliness and care, and (*or*) by the use of zinc and common soda. These are applied under various patent designations, but the resultant is the same in lasting benefit to the boiler.

The almost entire disuse of oils to the pistons and valves of engines has materially contributed to the present good order of the interiors, and it cannot be too much emphasized how well the modern engine runs

under these conditions. It has been claimed as a factor in the success of the water-tube boiler that the cylinders and valves of the engines are run without oil, but this system of only using the small portions passed in from the piston and other rods has long prevailed in many of our best cargo boats.

The evaporator has been already noted, and the advantages of its useful adjuncts, the feed heater and strainer, have also been fully discussed in papers read before the members of this Institution.

Maintenance and Repairs.

Setting Back Furnaces.—Among the numerous items of boiler repairs there have, unfortunately, still to be faced that of occasional distorted furnaces, and these, when found seriously out of shape, have to be dealt with either by replacing or by being forced back into their original shape. The usual procedure is to cross-stay the furnace at right angles to the direction in which the force has to be applied, properly support the *under* side of the furnace, and then restore to shape by pressure, going over the parts over and over again. Where the deflections have taken the form of pockets a hole has to be drilled in the centre for the gathering of the metal, and no difficulty has been experienced so far, even in very hopeless-looking cases. A hydraulic jack, with side arms and chocks, adapted to different diameters (Plate XLII.) has been in successful use for some time, and it need not be added in this age of steel boilers that these operations are carried out without the aid of heaters.

Failure in Plates and Stays.—Some few years ago engineers were troubled with what were then considered mysterious cracks in shell plates of double-ended boilers, and also in combustion chambers. The origin of these has been fully investigated, and their causes well understood. Of more recent interest are the cases of fracture of short combustion chamber stays, generally occurring at the backs at bottom, and occasionally in double-ended boilers at the top row in the wings. Examples of these are shown in Plates XLIII. and XLIV., and the causes are apparently due to unequal expansion. It is to be noted in each case that the stays have broken off next to the shell, that they show no signs of elongation, that the fracture is nearly square, and that no further trouble has occurred after they had been once renewed.

Boiler Tubes.—A question has often arisen as to the condition in which the tubes of a boiler ought to be kept, whether it is better to let them run uncleaned or with the same care and attention bestowed on them as the furnaces, and the question being rather an interesting one,

may be stated in the following way:—The percentage of tube surface in the heating surface of a boiler is about 85 per cent., and the effective heating surface 40 per cent—allowing 30 per cent. for furnaces and 30 per cent. for combustion chambers, etc.

Now, if we take this at 20 per cent. instead of 40 per cent. what becomes of all this efficient heating surface when the tubes have from ¼ inch upwards of hard scale on them, and does it not seem to point to true economy in working to have this important boiler factor kept at its highest state of efficiency? With the more modern boiler this is beginning to be seen, but with few exceptions, the older type of boiler (and this the one, too, that can least afford it) is allowed to be neglected until the corrosion, which has all the time been at work under the scale, eats through the metal and causes delay and expense by a general total renewal of the tubes at the age of six years and upwards. The writer is cognisant of one firm of shipowners who consistently laid up their vessels for a short time for the purpose of cleaning the boiler tubes, and these coasting vessels of 1,500 to 2,000 tons had never in one instance, up to a short time ago, retubed a single boiler, several of which had been running in continous work over eighteen years.

Guards to End Plates.—A point that might be added with regard to end plate guards is the absolute necessity of having them either fitted altogether separate from the boiler end (which is the best practice), or so made that soot or other matter is unable to gather there to the serious detriment of the plate and contiguous stays. The whole of the deterioration observable in this part could, in the writer's opinion, be absolutely done away with by attention to this most necessary detail, and all wasting can invariably be traced to the presence of undue heat.

Auxiliary Boilers.—Speaking generally the principal wear noticeable in auxiliary or donkey boilers is due entirely to the effects of heat and damp on the shell, this being most noticeable in the cases of vertical boilers in stokeholds where the wasting is invariably to be found on the side next to the main boilers. The cure for this is so obvious that it would be unnecessary to mention it were it not for the fact that so many boilers are rapidly depreciating for the want of a little protection when out of use.

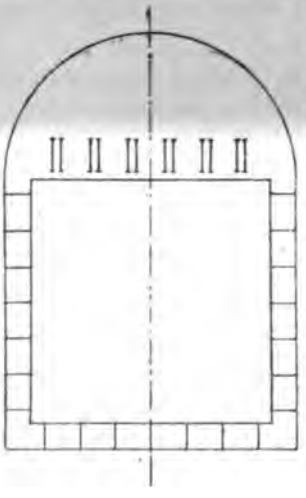
Boiler Covering.—It may seem out of the scope of this paper to mention tanks under boilers in connection with it, but it seems to have escaped general notice that it is as necessary to cover the *bottom* of a boiler as much as it is the *top*. It goes without saying that if a boiler could be kept perfectly cool that the extensive deterioration in tanks at

this part would cease, and the proper and efficient covering of the shell at the bottom has made a marked improvement in the case of the steamers which have, so far, adopted it.

In conclusion, the writer would emphasize the absolute necessity of maintaining a high standard of boiler excellence as one of the means by which we can continue to hold our maritime supremacy and the major portion of the carrying powers of the world.

DISCUSSION.

Mr. William Sisson (Gloucester) said that the point in the paper which was of the greatest interest to him was with respect to fracture of the flame-box or combustion chamber stays. He thought that he would be able to show later on that these fractures were caused by an action to which sufficient importance was often not attached, and, in fact, he doubted whether it was generally kept in view. He would illustrate what he meant by a diagram showing a cubical chamber encircled by an external receiver or boiler of cubical shape, but with semi-cylindric top. The crown of the internal chamber is supposed to be stayed by girder stays, and all the other five sides of the chamber to be directly stayed by screw stays to the external receiver. If the intervening space be occupied by fluid under pressure, what will occur? It would be seen on consideration that the inner chamber would be out of balance, for the pressure on its crown would be entirely unbalanced by any corresponding pressure on the crown of the outer box, while, of course, the pressures on all the other five sides were balanced by the pressures on the sides of the chamber; thus there was the total load on the crown pressing the inner chamber bodily downwards, and this could only be resisted by the side stays acting as cantilevers. Now, the state of things in the marine return-tube boiler was not so extreme as in the illustration given, but exactly the same thing occurred in kind, for it would be observed, on looking at Mr. Walliker's diagrams, that while the crown of the flame-box was entirely unstayed in a vertical direction to the shell, a con-



siderable portion of the lower side of the flame-box was so stayed, and there was a total downward pressure on the flame-box amounting to the difference between the load on the vertically unstayed crown and the load on the vertically unstayed bottom, tending to force the flame-box down into the boiler, and this force must be practically entirely resisted by the action of the side stays as cantilevers.

It would be remembered that Mr. Walliker mentioned four points with regard to stay fractures adverted to:—

(1) That it was the short stays that broke.

(2) That they broke off next to the shell plate, and not next to the flame-box plate.

(3) They showed no signs of elongation, and that the fracture was nearly square.

(4) That no further trouble had occurred after they had been once renewed.

He ventured to say that the above theory that the back stays were compelled to act as cantilevers to compensate for the want of balance in the top and bottom pressures on the flame-box would explain all Mr. Walliker's observations; for (1) the short stays must break because a given vertical deflection of their ends imposed on them the greatest stress, especially when it was considered that the deflection of a cantilever varied as the cube of its length. (2) These stays broke next the shell simply because the shell plate was thicker, and did not buckle as the flame-box plate did, this being thinner, and therefore the bending moment on the screw stays was concentrated next the shell plate. (3) Since the fracture was transverse and the stays had screwed threads on them, it would be expected that they should show no sign of elongation and that the fracture should be square. (4) The reason that no further trouble had occurred after these short stays had been renewed after fracture was simply the fact that these stays, because they were short, had practically the whole downward load to bear, but that when they broke, the flame-box sunk slightly, and thus brought into action the whole, or nearly the whole, of the stays in the back. This point was again emphasized by the remembrance that with equal loads the deflection of a cantilever varied as the cube of its length; thus, if the lower stays in the flame-box back were half the length of the upper, a sinking of the flame-box in the boiler to such an extent as to cause fracture of the short bottom stays would only cause a stress of about one-eighth of the breaking stress of the upper stays, double the length. He, therefore, thought that he was entitled to claim that the theory advanced explained the phenomenon

fully. It might be remarked that the unequal expansion of the flame-box and the boiler back accentuated the fact above dealt with, and especially so when an arch back flame-box was gusseted to the back plate of the boiler, for in such case the differential expansion of the flame-box must take place almost entirely downwards, and thus the effect upon the short lower stays was rendered still more acute. Arising out of this question of arch back flame-boxes he would venture to maintain strongly that the proper way of staying them was not by means of gusset plates, tying them in such a manner that expansion was difficult and prejudicial but by means of palm stays; and he would say that though his experience was by no means as large as that of many at the meeting, yet such as it was, it was entirely in favour of properly constructed arch backs, stayed by palm stays, or, if large, by a row of T-end stays in addition. He had made such boilers for all pressures from 80 to 160 lbs., and had never in any single case, had the slightest trouble, either during test or in actual work. There were three points, however, that needed to be attended to:—(1) There must be no flat upper portion extending from the edge of tube plate flange, but, as shown in Mr. Walliker's diagram, the radius must commence there. (2) Remembering that the arch back flame-box was simply one-fourth of a furnace, the thickness of plate must be made fully equal to what would be required in a furnace of the same radius and length between side plates. (3) Seeing that the arch back was practically one-fourth of a furnace, and that the duty of the palm stays was simply to form practically an abutment for the arch where it ended at the tube plate, the palm stays must be carried as far over on to the top of the flame-box as was practicable. Of course a moment's reflection would show that it was quite erroneous to think that the upper row of tubes could be of any use as pillars to resist the stress of the arch back, because their duty was to tie the front plate of boiler to the back tube plate. With regard to the practical question of how to minimise the tendency of these back stays to break, he would suggest three things:—(1) To get as much rake in the back plate of flame-box as possible, and to insert the screw stays at right angles to the back plate of flame-box. This reduced the difference of load downwards and pressure upwards on the flame-box, the effect of which was detrimental. (2) To use stays nutted inside the flame-box. This would stiffen the back plate of the flame-box and fix the stays more firmly there, thus tending to give the stays the advantage of a greater bending moment next the flame-box plate and diminish the extreme bending moment next the shell back plate. (3) To turn the thread off and reduce the bodies of the *shorter* stays to a

diameter considerably below the bottom of the thread, and it would be well, in addition, to increase slightly the diameter of all the stays. This would enable the short stays to yield somewhat without fracture, and allow the flame-box to sink in the boiler and bring the unbalanced load upon the whole of the stays to a greater extent.

Mr. R. HIRST said Mr. Walliker was quite right in urging that a great deal more attention should be paid to the question of the water spaces in boilers. He was also right in reference to the cleaning of tubes. As to arched combustion chamber backs, he had made some very careful notes of boilers when under water pressure, and he found, in the first instance, that the back first began to open out at the working pressure, and his idea had been that this was due to a crushing strain; but it was not, it was due to the pull on the end plates. They would find a movement of about $\frac{1}{32}$ of an inch at the working pressure of 150 lbs., and a further movement which would measure about $\frac{3}{32}$ inch, say at 300 lbs. or 320 lbs. per square inch. This opening out was entirely due to the pull on the end plates. At the same time he was of opinion that the curved back was not the correct form of firebox. He thought a flat top, like the locomotive firebox, was the best form for high pressures. With regard to deterioration and waste, he was of opinion a good deal was due to the lack of washing out. Washing out a boiler was a most important matter and helped to prolong its life. Then there should be no sudden blowing down either from steam or hydraulic pressure, the collapse and strains caused by the sudden release being much more than was generally known. Again, as to the question why the bottom portion and the back plates of the combustion chamber always waste the quickest. This was due to the leaving in of dirt and hot ashes when the boilers were either run out or blown down. If these box bottoms were raked out, the bottom part of the plate ought to last as long as the top part; but a wooden rake should always be used in a boiler bottom when raking out scale and sludge; as a great many leaky rivets in the bottom circumferential seams were caused by the use of the iron rake. They would always find that furnaces suffered the most from pitting and grooving at the line of the firebars when the water spaces were narrow; hence the reason why water spaces should be kept as wide as possible and easily accessible for cleaning, then boilers would last much longer.

Mr. J. R. FOTHERGILL said he desired to thank Mr. Walliker for his very interesting and practical paper. He had listened with much interest

to the remarks of Mr. Sisson, and thought there was a great deal in what he had pointed out. Mr. Hirst's experience was of considerable importance, and when he related that, in testing boilers under hydraulic pressure, the gauges showed very little extension—$\frac{1}{32}$ inch in the combustion chamber at the working pressure, yet at twice the working pressure (Lloyd's requirement) there was an additional extension of $\frac{3}{32}$ inch—it appeared to him (Mr. Fothergill) such evidence was in itself sufficient to show there must be great straining, detrimental to the original strength and tightness of the structure. He took it, particularly in these days when the material was thoroughly tested and analysed, that hydraulic test was essentially a test of workmanship. It appeared to him, particularly in the face of such evidence, how far Lloyd's were justified in continuing to insist upon double the working pressure. Did Mr. Hirst hold that it was right and desirable to have a double test pressure, say, for a working pressure of 250 lbs.? He felt sure the majority of practical engineers would agree with him that it was unreasonable to demand such an excessive straining pressure to be put upon any boiler, and this was fully recognised in the Navy. Then, as to the question of blowing down. He was under the impression that, at the present day such practice was out of use; it certainly was a great mistake to blow boilers down, and it not only facilitated rapid contraction but materially hardened any scale that might exist. Undoubtedly the proper plan was to allow the water to cool, and then run or pump it out. Of course there were exceptional cases when it became necessary to blow. He fully agreed with Mr. Walliker as to the deleterious effect of allowing ashes to accumulate in the back ends, but he was very much afraid in cargo steamers this would not be overcome at sea, unless the engineers themselves cleaned them out.

Mr. G. H. Baines was glad to find that the remark of Mr. Fothergill as to the testing of boilers at double the working pressure elicited such a cheer throughout the meeting. He hoped the echoes of that cheer would reach a certain place where, no doubt, these matters were carefully weighed. The firm with which he was connected had just built a pair of boilers, of the ordinary cylindrical type, for a working pressure of 255 lbs. His colleague, Mr. Mudd, had had considerable correspondence with Mr. Milton, who did not see his way (Lloyd's did not see their way) to dispense with double the working pressure, and they tested those boilers, 11 feet diameter, up to 510 lbs. hydraulic pressure to the square inch. His colleague had the satisfaction of seeing those boilers withstand

that pressure as perfectly as if they had been tested at 320 for 160 lbs. pressure, showing the perfection to which they had arrived in boiler building. They had hoped that the plan of the Admiralty, which gave a certain amount of latitude—not exacting double pressure—would have been followed in this case. All practical men must feel that, seeing materials were tested at every point before they came to the boiler builders, hydraulic pressure up to double 255 lbs., viz., 510 lbs., for their boilers was not necessary.

Mr. R. HIRST said when the boilers referred to by Mr. Baines were tested to 510 lbs. of water, he made a wooden frame and put it on all round the boiler, and gauged the distances very carefully from the side, top, and bottom. Usually boilers under pressure went up—that was, the sides elongated and formed an oval. The boilers in question went up an eighth of an inch. There was no mistake about it. But there was absolutely no indication that there was any water in the boilers. He took the girth of the boilers with a steel rule, and there was not a $\frac{1}{32}$ inch difference in the circumference; they each measured the same. But with reference to what Mr. Fothergill had said on the subject of testing, he considered that Lloyd's were quite right in adhering to the double pressure. He had an instance in his mind of a firm who put a pressure and a half upon their double-ended boiler, when the shell gave way. The working pressure of the boilers was 160 lbs., and according to their own records there was only 240 lbs. per square inch showing on the gauges when the boiler gave out.

Mr. ROBERT THOMPSON said that when the matter had been under discussion by Lloyd's committee, the objection did not seem to be so much against reducing the double pressure as that the Board of Trade would not like it. It had struck him that considering our warships were built without Lloyd's or Board of Trade inspection, they might be trusted to carry on the mercantile marine with a slightly reduced pressure for Lloyd's test purposes. He was not without hope that in a short time they would have this pressure reduced. At the meeting Mr. Marshall was very strong about it, and so was Mr. Boyd, Mr. Seaton, and many others. To his mind, the arguments against double pressure were not answered by the technical staff of Lloyd's. The general impression of the members after the meeting was that the day was not far distant when the pressure would be reduced. With regard to the paper by Mr. Walliker, he had often wondered, as a shipbuilder, why engineers covered two-thirds of the boiler's circumference with non-conducting material, and left the bottom unprotected.

MR. J. F. WALLIKER'S REPLY.

Mr. J. F. WALLIKER, replying to the discussion, said, the time being very short, he would only say a few words. Mr. Sisson's theory of expansion fairly coincided with his own. As to combustion chambers' tops stayed by gussets, they had a large experience of them; and, so far as he knew, they had been found quite satisfactory, and he would add that there were no boilers within his knowledge which had the upper portion next to the tube-plate flange lying unsupported, and he was not at all surprised to find such a design gave trouble. He recalled one instance in which the top of the combustion chamber buckled at the test when at a little below the double pressure, and enquiry showed that a plate had been put in which was less than rule size; and this afforded, to his mind, a striking illustration of the desirability of adhering to the higher test pressure, which some members were so desirous of reducing. As to the flat and rounded tops, they had seen both doing good work, and, except theoretically, he could recognise no preference.

Mr. Fothergill had again returned to the question of a double test pressure: he had already given one instance of a collapse occurring owing to a thin plate. He might be allowed to quote another instance of the need of adhering to their present rule. This was a case of an auxiliary cross-stayed boiler, in which a stay broke when near the double test pressure, starting all the riveting in its vicinity. Upon examination the stay was found fractured halfway through. If a high test pressure had not been put on the fractured stay would have been undiscovered, and might have resulted in disaster.

Mr. FOTHERGILL—Did the pressure fracture the stay?

Mr. WALLIKER—No, it was an old fracture. He was of opinion that it would be a mistake to alter the present regulation of testing new boilers to twice the working pressure. It entailed no hardship when universally enforced, and he could not see where, if they once began to make reductions, their friends would like them stop.

On the proposition of the PRESIDENT, a hearty vote of thanks was accorded to Mr. Walliker for his paper, and it was agreed that the discussion be re-opened at some future meeting.

MARINE BOILERS, PARTICULARLY IN REFERENCE TO EFFICIENCY OF COMBUSTION AND HIGHER STEAM PRESSURES.

By J. R. FOTHERGILL, Vice-President.

[Read before the Institution, in Cardiff, on June 25th, 1896.]

As each year passes, the development in marine engineering so progresses, that at the present day we have reached that high standard of efficiency which makes it difficult to realise how further economy can be obtained without a material increase in the boiler pressure.

Past experience shows that no essential development in the marine engine has taken place without considerable hesitation, time to perfect detail and isolated trials proving beyond question such alterations were productive of economy. The introduction of the "compound" followed by the "triple" in each case took considerable time to develop before they became universal; the "quadruple" at the present day is quite the exception, and it is difficult to realise how it can become the accepted engine without a material increase in the working pressure.

Not only engineers, but shipowners are much concerned as to the solution of this problem, and particularly, if we are to go to higher pressures, what is to be the accepted type of boiler, nor need we be surprised at this when we consider the controversy taking place as to the various merits or demerits of the water-tube type.

Is this increase in pressure to take place, or are we to accept 180 to 200 lbs. as the limit?

Have we not at each marked increase in pressure over and over again heard the old argument, increased pressure means increased temperature, with all the attendant difficulties, re-packings, oils, leaky joints, boiler troubles, etc., eloquently expounded, but of what avail? Is it not an inherent characteristic of the engineer to go-ahead? One might as well try to push back the tide as prevent the engineer in his march of progress. Material progress cannot be made without failures, and well that it is so, for experience so gained builds up, as it were, a solid foundation on which to establish ultimate success.

The greatest difficulty in the past has been the manufacture of suitable boilers to meet the requirements of increased pressure. Demand and necessity for high quality material has been met by the energy and vigorous activity of the steel maker. Capable machines, suitable and able to deal with any thickness of plate and diameter of rivet, are obtainable, and the furnace manufacturers have kept well abreast of the times.

Although under these circumstances we can construct boilers with tightness and absolute safety to withstand any working pressure, yet we must not overlook the fact that a boiler has other functions than the mere certainty of being able to stand an enormous bottled-up pressure. It is of vital importance that a boiler should be considered an apparatus whose essential functions are:—Evaporation and combustion; the rate of evaporation depending upon the efficiency of combustion and heat generated.

We may reasonably assume increased boiler pressure looms in the near future, and although it is impossible to foresee to what pressures we may ultimately go, yet 250 to 280 lbs. may be considered within the bounds of probability, it thus becomes of the utmost importance to consider whether the present type of cylindrical return-tube boiler with circular furnaces is the most efficient as an apparatus for combustion, generation of heat, and transmission of that heat to the water.

It is freely admitted this type of boiler has been, and is, up to certain pressures, the most simple, the most "get-at-able," and serviceable marine boiler of any type introduced, but does this hold good for higher pressures.

The important objections seem to be weight, thickness of plate, particularly such plates as are heating surface, heavy close staying, and especially small diameter of furnaces.

The writer is well aware small furnaces are occasionally used, but this is usually due to some peculiar necessity and not from choice.

Neither the Board of Trade nor Lloyd's rules prevent the use of fairly large furnaces of the corrugated or ribbed types under high pressure, but the necessity for keeping the diameter of the boiler shell as small as possible to avoid exceptional thick plates and additional weight, etc., necessitates the use of furnaces of small diameter.

All engineers of practical experience fully appreciate the efficiency of large furnaces, and this is readily understood if we consider what takes place when fresh coal is thrown on the fire of a furnace in active condition. The coal at once absorbs heat, which disengages the bitumin-

ous hydrocarbon constituents by volatilisation, or, in other words, generates the gaseous portion of the coal by distillation. Until this process is completed the fixed carbon or coke is not consumed. Volatilisation is the most cooling process in nature, due to the quantity of heat which is directly converted from the sensible to the latent state.

It is, in particular, due to this cause that heavy firing is so disastrous, and should be carefully avoided.

As the hydrocarbon gases are volatilised by the first application of heat and pass off, hydrogen having a greater affinity than carbon for oxygen, readily unites with oxygen to the production of water—steam. The carbon thus liberated must be supplied with its necessary proportion of oxygen to the production of carbonic acid, otherwise it will be precipitated in an extremely divided state and pass away as smoke, or, if from various causes the supply of air to the gases should be exceptionally small and badly distributed, carbonic oxide will be produced with serious loss in the amount of heat generated. For carbon consumed to carbonic acid evolves 14,500 units of heat, which, if consumed to carbonic oxide, would yield 4,400 only. Although carbonic oxide may be produced under exceptional conditions, yet, fortunately, it does not appear from the analysis of funnel gases to be generally present, and when present it is usually in inappreciable quantities.

To ensure complete combustion to the generation of heat, it is essential that not only shall the air supply be sufficient, but that it shall be properly distributed in such manner as will readily facilitate completion of the combustion of the hydrocarbon gases as they leave the surface of the fire as well as the fuel on the bars.

This question of air supply is one of considerable difficulty, and has exercised the ingenuity of many capable men. This difficulty is materially increased by reducing the diameter of the furnace, and thus the height above the fire.*

It is of material importance that the necessity for maintaining at high temperatures the hydrocarbon gases as they are evolved should be thoroughly understood. Hydrogen effectively unites with oxygen at not less than 600 degs. Fahr., and carbon with oxygen at not less than 800 degs. Fahr. The higher they exceed these temperatures within certain limits the more readily they unite and the less surplus oxygen required. Volatilisation being the most cooling process in nature, it is imperative the greatest consideration be given to raising the temperature of the

* See the writer's paper, "Combustion of Coal and Prevention of Smoke," read before the Institution, November, 1892.

hydrocarbon gases as they are evolved, that they may immediately take up and unite with the necessary oxygen to complete combustion and generation of heat.

Perhaps in this respect the most serious difficulty to overcome is that great bugbear—heavy firing. Unfortunately, this appears inevitable where the manipulation of the fires is left to the capricious and prejudicial bias of the stokehold. Large quantities of coal thrown on the fire at once reduces the temperature, and frequently to such a degree that the gases evolved cannot take up the oxygen required, and thus they pass away, forming the huge volumes of smoke so commonly seen immediately after firing.

The smaller the furnace the greater the evil, in that the furnace crown is very much closer to the fire; in fact, without very careful and judicious firing—and where will you find it in the ordinary mercantile marine?—the surface of the fire is so close to the crown that immediately the gases are evolved they come in contact with the crown plate, and if we consider that at 250 lbs. pressure, the temperature of the water, and hence the plate is, say, 400 degs. Fahr., we at once realise the deleterious effect this must have in keeping the temperature of the evolved gases far below that necessary to complete combustion. Again, the smaller the furnace the less the sectional area above the fire, and thus the velocity of the gases leaving the furnace require to be considerably increased; moreover, this velocity is greatly augmented by the necessity to largely increase the consumption per square foot of grate, due to the small grate area obtainable.

To obtain this necessary high velocity of the gases a lofty funnel with high temperature of the escaping gases must be used or some system of induced draught. High velocity of the escaping gases is, in many respects, a most objectionable feature. Time is an essential element in the completion of combustion, in the union of carbon with oxygen, and in the transmission of heat to the water. At this high velocity the temperature of the gases as they escape from the tubes into the uptake must be abnormally high. True, much of this heat may be utilised in various ways, but it is a costly process.

There is another important feature which does not appear to have attracted sufficient consideration, namely, the gases of complete combustion do not transmit heat by radiation, but by conduction. The sectional area through the tubes being in all cases larger than the outlet from the furnace facilitates the gases passing from the furnace at high velocity into the tubes in the most direct course without coming in close contact

with the large heating surface of the combustion chamber, and probably the suction draught may be so great, when large quantities of coal are burnt per square foot of grate, as to draw the whole of the gases through the lower rows of tubes leaving the top rows useless.

In Fig. 1 (Plate XLV.) the writer has endeavoured to depict the course gases of high velocity, due to excessive funnel or induced draught, will probably take when passing from the furnaces into the tubes, and from which it will be seen that practically a large percentage of the combustion chamber heating surface is rendered of little or no use, due to the inability of the gases to transmit their heat other than by conduction.

It would appear as though many of the objectionable features referred to are obviated in the water-tube boiler. Of course there are water-tube boilers and water-tube boilers, as there are in most other things, some to be entirely avoided, others specially designed and satisfactory for certain purposes only.

For the purpose of this paper, a type of water-tube boiler known as the Babcock and Wilcox is given in Fig. 2 (Plate XLV.). The writer has selected this particular boiler as one that he is somewhat acquainted with and suitable to the requirements of the ordinary mercantile marine. He specially desires to say that he has not selected this boiler in detriment to other types of water-tube boilers, but principally because he has evidence of its success, as fitted in several steamers, in confirmation of which he gives the following :—Mr. Alexander Gray, consulting engineer, Newcastle-on-Tyne, who has under his supervision four steamers fitted with Babcock and Wilcox boilers, informs the writer they are giving the greatest satisfaction, both as to consumption and endurance; in fact, the results are so satisfactory that they are specified to be fitted in two new steamers now building.

The writer having received the following letter from Mr. J. Spear, superintendent engineer to Messrs. Wilson, Sons, & Co., Limited, Hull, ventures to give it *in extenso*, believing it will be considered most interesting :—

DEAR SIR,—I believe we were the first in this country to try Messrs. Babcock and Wilcox's water-tube boilers in a sea-going steamer, this was over three years ago in our s.s. "Nero." This boiler is running quite satisfactorily, and the ship has not lost a day for boiler repairs up to the present. A few tubes in the feed-water heater have been renewed, and probably the whole of them will require renewals shortly, as they appear to corrode very rapidly. In the boiler proper only one or two tubes exposed to the fire have been renewed at a trifling cost. About twelve months ago we fitted a new steamer, the "Hero," with a pair of boilers by the same makers, but somewhat

modified in details, no heater was fitted, and the tubes were larger in diameter. We have had considerable trouble with the bottom row of tubes in these boilers, and, in consequence of this, in a third ship, the s.s. "Cameo," which we have had fitted with Babcock and Wilcox boilers we have reverted to the smaller tubes (slightly larger than the "Nero's"), and up to the present no tubes have given way, neither have any repairs been required to these boilers.

As regards consumption there is not much either way, comparing the s.s. "Hero," "Nero," and "Cameo" with our most economical forced draught and ordinary boilers they fall slightly short, but still give as good results as ordinary averages with the ordinary boilers.

I think the direction in which economy in consumption is to be sought for in the water-tube boilers is in the arrangement of baffles over or amongst the tubes, so as to properly utilise the heat that frequently too easily goes up the funnel.

We have, as you are probably aware, one steamer fitted with four Belleville boilers. We have not been fortunate in our experience with these, but perhaps this has been from causes other than the design, although it is certain that the Belleville boiler is more difficult to clean and repair than is the Babcock and Wilcox, whilst with us the consumption has been greater with the Belleville than with the Babcock and Wilcox.

Yours truly, etc.

In the Babcock and Wilcox type of boiler we have a large grate area suitable to the best conditions for complete combustion. The furnace is supplied with two doors sufficiently large to facilitate the distribution of the fuel, and at that convenient height which gives the fireman complete charge over his shovel, a matter of no small importance, particularly with untrained men. By firing at each door intermittently you have always one side of the furnace incandescent when the other is being fired, and thus the hydrocarbon gases evolved are readily heated up to the necessary temperature to their union with oxygen to complete combustion and generation of heat.

The height of the lower row of tubes above the fire offers a great advantage for the supply of air to the surface of the fire.

The writer is not aware whether the following arrangement has been tried, but it would appear to offer some advantages :—Say, for a distance equal to one-third the length of the grate, specially designed slabs of fire-brick be suspended to the underside of the bottom row of tubes, or otherwise fixed. As the fire burns down and becomes a mass of incandescent coke, the firebrick would store up a considerable amount of radiated heat, which in its turn would be given off in heating up the early gases as they are evolved to complete combustion and production of heat. Such an arrangement would necessitate placing the coal principally at the front of the fire and pushing it back on the grate after the gases were given off.

It will be seen by the drawing (Fig. 2) that provision is made to deflect the gases in their passage through the boiler. This is one of the

most important features of the water-tube boiler, and due to this not being appreciated in the earlier types, was, undoubtedly responsible for much of the loss of efficiency in those boilers, as the gases of combustion passed direct from the fire to the funnel without coming sufficiently in close contact with the heating surface. There is, no doubt, the most efficient position in which to place these deflectors is open to some argument. Whether they should be horizontal or vertical, viz., in a line with, or at right angles to, the tubes is debatable. Horizontal deflectors offer convenient shelves for the accumulation of soot and small ashes, etc.

The writer in his forced draught trials had strong practical evidences of increased efficiency, by keeping the gases passing through the boiler under slight compression. Take the case of the s.s. "Iona," one of the steamers tested by the Committee of the Institution of Mechanical Engineers and under the writer's supervision, and fitted with his system of forced draught. During the whole of the trial the damper in the funnel was only one-sixth open; this gave just sufficient compression to bring the gases into intimate contact with every square inch of heating surface, both in the tubes and in the combustion chambers, to the greatest advantage in the transmission of heat, as shown by the low temperature of the funnel gases. From frequent trials, all other things being the same, the difference in maintaining steam with the damper full open and only open one-sixth was most marked. It will be readily understood this closing of the damper cannot be utilised with natural draught. It is more than probable the application of some such system of slightly compressing the gases in water-tube boilers would do much to improve their efficiency and obviate the necessity for deflectors and baffles, which in itself would be a considerable improvement.

In a paper of this limited description it is impossible to consider the mechanical structure and the many details necessary to an efficient boiler, and which must very largely determine the type of boiler of the future. There is no doubt the present type of boiler, if it does die, will die hard, due to its well-earned popularity, and in all probability it will only be the demand for higher pressures that will kill it.

The writer feels he has left much unsaid, in fact, that he has only touched the fringe of this important subject, yet he hopes sufficient material will be found to promote useful discussion, for, after all, the greatest value of a technical paper is not so much the subject-matter it contains as the discussion it promotes and the ventilation of different opinions.

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tube boilers. So far, the water-tube boilers in use on board had not been an unqualified success, especially as regarded ec fuel, but this did not mean that the present system of water-tub could not be improved upon, and he had no doubt that means wc be devised to remedy that defect and to make the water-tube b economical, or more so, than the ordinary boilers now in use. I like to be allowed to emphasize in a few words the point of Mr. gill's closing remarks in his paper, namely, as to the object professional institutions. They gave the necessary opportunity ing papers on mutually interesting topics, and examining the the light of experience and observation by means of discussion the success of the North-East Coast Institution had been main the impartiality of the President and Council in directing its w the faithful way the Reading Committee had fulfilled its duties had suppressed the inclination to trade advertising, encoura competitive spirit of its members, and given desirable opportu young engineers and shipbuilders, who might otherwise have in obscurity, to exhibit their abilities and ideas. This, again, an advantage to firms, affording as it did an opportunity of fi places of those who retire from active work with men of known ments in the higher walks of their business. If the lines o institutions were drawn on the same basis of technical and matters, and cut off where the advertising element came in, thei would be irreproachable, even in this commercial and competi He trusted that what Mr. Fothergill had said in this connectic incite members to give their knowledge and ideas more latitude, the medium of papers for discussion, thus advancing themse benefiting others and so fulfil the aims of the Institution. I

Mr. W. Reavell exhibited in the room two illustrations of somewhat different types of the Babcock and Wilcox boiler, together with a model of the type of header used in the construction of the boiler. Concerning the note addressed to Mr. Fothergill by Mr. Gray, the sea trials, he said, were expected next week of a third steamer, the largest vessel of the turret type yet built—the "Norman Isles"—which was also fitted with Babcock and Wilcox boilers. There were also two other turret ships for which Mr. Gray was consulting engineer, owned by Messrs. Peterson, Tate, & Co., Newcastle, in addition to those mentioned in the paper, which were in course of construction, and they were also to be fitted with these boilers. With regard to that portion of the letter sent by Mr. Spear which referred to the heater in the boiler of the "Nero," it should, of course, be pointed out that the heater was not a necessary component part of the Babcock and Wilcox water-tube boiler, but was fitted in this case for experiment. The type of heater used in the boiler of the "Nero" merely consisted of a series of tubes placed above the boiler itself, resting on the horizontal tubes, and so arranged that the water was pumped through the tubes of the heater on its way to the boiler. The trouble which was referred to in the letter occurred very soon after the boiler was first put to work, but this was remedied by the fitting of zinc rods inside the lower tubes of the heater. They considered that the fitting of zinc rods in feed-water heaters was quite sufficient to make tubes in the heaters last as long as the tubes in the boilers. He agreed with Mr. Walliker as to the advantage of using zinc in marine boilers. There was another point touched upon both in Mr. Spear's letter and Mr. Fothergill's paper to which he should like to refer. Engineers very frequently compared the water-tube boiler with the Scotch type, *plus* forced or induced draught. That, he thought, was a little unfair, because any type of forced or induced draught added to a boiler of the Scotch type could be just as well added to the boiler of the water-tube type. It should be judged on its merits independently of the efficiency of the boiler itself. That was to say, if they wished to compare the types of boilers, it was only fair to take the boilers themselves without any forced or induced draught. Or if they wished to compare them with forced draught, let the same type be put on to each, and make the conditions exactly the same. In the latter part of his paper, Mr. Fothergill discussed the question of baffles, and expressed the opinion that all that was needed to make water-tube boilers as satisfactory as the best type of Scotch boiler was to see that the baffles were so arranged as to get every part of the heating surface made effective, or else to have a slight compression in the furnace and around the tubes so that

the gases touched every portion of the heating surface. The difficulty of ensuring that all the heating surface is used applies equally to boilers of the Scotch type; note for example the growing use of Serve tubes and retarders. The lines which Mr. Fothergill went on with regard to the "Iona" were possibly the correct ones. Mr. Alexander Gray had also devoted some attention to this question. In some experiments on two turret ships with Babcock and Wilcox boilers all the baffles amongst the tubes were removed: in one case, restricting the draught area at the top of the boiler over the top horizontal tubes as much as possible, making it just sufficient to enable the boilers to give the steam freely that was required. In the other case, the baffles which were fitted on the tubes in different positions were increased, and then observations were taken to see which was the better method, with the result that they could not discover any difference in economical working. From the point of view of cleaning it seemed to be an advantage to remove the baffles, because they simply formed ledges for the accumulation of soot.

Mr. J. Nodder said they would be a little surprised to know that he was considerably in agreement with his friend, Mr. Fothergill. He agreed with the author of the paper in that the present type of boiler intended to die very hard. The water-tube boiler had not got everything its own way yet. In his paper Mr. Fothergill stated, "It will be seen by the drawing that provision is made to deflect the gases in their passage through the boiler." Most of them would be aware of some boiler tests recently made at West Hartlepool. They were working at 255 lbs. pressure, and were fitted with Serve tubes and retarders, working with the Ellis-Eaves induced draught. The results were very remarkable. Indeed, they represented the ideal condition of a pound of coal per horse-power. That was something to be proud of, and it was arrived at by the means recommended by Mr. Fothergill of hindering the escaping gases from going into the funnel, and so taking the heat with them. The Ellis-Eaves system did that. When the water tubular boiler came up to this efficiency he would support it, and should be pleased to apply to it the Ellis-Eaves system of induced draught and Serve tubes.

Mr. Reavell, replying to Mr. Robert Thompson, said the weight of a Babcock and Wilcox boiler was 50 per cent. less compared with an ordinary boiler doing the same work under similar circumstances.

The discussion was adjourned.

MEMOIRS.

EDWARD REYNOLDS.

EDWARD REYNOLDS was born in London, on October 7th, 1825. His boyhood was spent in Herefordshire, where he went to school; and he completed his education at King's College, London. In 1844 he was apprenticed to Messrs. Adams & Co., engineers and carriage builders, Old Ford, London, and remained there for two years. During this period he had the opportunity of becoming acquainted with early experiments on Henson's flying machines, with which the firm were concerned. In 1846 he became chief draughtsman in the locomotive department of the Eastern Counties Railway, where he remained till 1850, and he was instrumental in the alteration of the locomotives from the then 5 feet gauge, having bar frames, to the 4 feet 8½ inches gauge, which necessitated the substitution of slab frames. From 1850 to 1852 he was draughtsman and manager of Mr. Thomas Kennard's office, Adelphi, London, where he was largely engaged in designing Warren girder bridges and bridges generally. From 1852 to 1860 he was chief engineer to the Butterley Iron Co., near Alfreton, and during this period he remodelled a large portion of their machinery, some of which was antiquated; several of the engines and locomotives he designed are still at work there. In 1860 he joined Mr. (now Sir Frederick) Bramwell in partnership, which continued until early in 1863, when he became engineer to Messrs. Naylor, Vickers, & Co., Millsands, Sheffield, and was engaged in the construction of their River Don Works. In 1872 he became a managing director, and continued in this position for the rest of his life. Among the noticeable machines designed by him at these works are the large forging presses, the construction of which was commenced in 1882; they have a long-stroke ram, bearing against the spherical end of an inverted T-shaped cross-head, which works between guides and carries the forging face. Before the actual pressing the slack is taken up by water at a lower pressure; this plan he had adopted some time before for general hydraulic work, possessing as it does the advantage that smaller pumping engines can be employed. In 1894 he became a director of the Elmore Copper and Wire Companies, and took an active interest in their management

and in the technicalities of their manufacture. During the latter part of 1894 his health had been failing, and a chill contracted at the beginning of the following year hastened his death, which took place at Sheffield, on 12th January, 1895, in his seventieth year.

RICHARD ELIHU DICKINSON.

Richard Elihu Dickinson was born in Liverpool, on the 10th April, 1849. He was there apprenticed to a shipping firm, which is now merged into the White Star Line, and received a good commercial grounding. His tastes, however, inclined to mechanical engineering, which he studied both theoretically and practically. At the age of twenty-two he commenced business as an engineer and ironfounder at the Cleveland Engine Works, Birkenhead, where he constructed overhead cranes and special machinery. At that time he became connected with some Portuguese mines, and was resident abroad for a time, erecting the necessary machinery. Turning his attention early to the application of steam power to tramway cars, he built a considerable number, which were used in Dublin, Wigan, and elsewhere. Their advantage lay in the absence of smoke and the small consumption of fuel. Closing the Birkenhead works, he removed to the Saville Street Engineering Works, in Sheffield, where, in connection with the Clay Cross Company, these steam tramcars were constructed. While in Sheffield he was greatly interested in the manufacture of steel, as well as in general engineering work, and was appointed manager of a new concern started at Barrow-in-Furness, in which the late Mr. Daniel Adamson was interested. There he remained until 1887, when he became manager of the steel and iron-works department of Messrs. Palmer's Shipbuilding and Engineering Company, at Jarrow-on-Tyne, where he put several large steel-melting furnaces and a 36 inch bar mill. In 1891 he became managing director of the Bowling Iron Company, Bradford, where he remained until his death, which took place after a brief illness on the 12th May, 1895, at the age of forty-six. In the year 1889 he became a member of the North-East Coast Institution, but took no active part in its proceedings.

WILLIAM JENKINS.

William Jenkins died at Consett Hall, on May 14th, 1895, at the age of seventy years. He was for nearly a quarter of a century general manager of the Consett Iron Company, Limited, which position he relinquished in August, 1894, when he was elected a director of the

company. Mr. Jenkins had been in ill health for some considerable time prior to his death. He was born at Merthyr Tydfil, on February 23rd, 1825, and occupied various positions at the Dowlais Iron Works for many years, having at the time of his coming to Consett, in 1869, the entire charge of the commercial part of that company's business. On the formation of the Orconera Iron Ore Company, Limited, by the Consett Iron Company, the Dowlais Iron Company, Fried. Krupp, of Essen, and the Messrs. Ybarra, of Bilbao, Mr. Jenkins was appointed managing director. His long and most important services in connection with the Consett Company made for him a widespread reputation, and he was very highly respected throughout the county of Durham, of which he was a justice of the peace. Mr. Jenkins was chairman of the Consett Local Board, and on the formation of the Durham County Council was elected a county alderman. He also filled many other important positions in the county. He became an Associate of the North-East Coast Institution in the year 1887.

WILLIAM KILVINGTON.

WILLIAM KILVINGTON was born on the 18th of July, 1852, at Hartlepool, of which his father held for many years the post of clerk to the Guardians. He began his career in 1867 as an apprentice at the engineering works of Messrs. Thomas Richardson & Sons, West Hartlepool, where he spent five years in the pattern shop, erecting shops, and drawing office. He then attended for a session the College of Physical Science at Newcastle-on-Tyne, devoting himself mainly to the study of physics and mathematics, in which subjects he attained considerable distinction. Mr. Kilvington's long connection with the North-Eastern Marine Engineering Company commenced in 1873, when he entered its works at Sunderland as a draughtsman. In the following year he was appointed head of the drawing office, of which he had charge until the end of 1882, when he was transferred to the Northumberland Engine Works, the company's new establishment at Wallsend, as manager. That post Mr. Kilvington held for nearly thirteen years, having entire control of the works, from which, on an average, twenty to twenty-five sets of marine engines were turned out annually, as well as high pressure pumping engines for waterworks, etc. He was responsible for upwards of 1,500 workmen and for the design of machinery, for the preparation and signing of specifications, and for estimates of costs for tendering. Gifted with natural ability of a high order, he showed great tact in dealing

with the ever-recurring labour problems of the day, winning alike the confidence of the workmen and the esteem of the staff, with the members of which he was in constant contact. In addition to his official duties, he was a director of the Walker and Wallsend Union Gas Company, and for many years a member of the Wallsend Local Board. He took a great interest in scientific and technical instruction in the mid-Tyne district, and was a member of several scientific bodies. He joined the North-East Coast Institution of Engineers and Shipbuilders at its inauguration in November, 1884, was elected a member of Council in 1887, and Vice-President in 1890. He took a lively interest in the affairs of the Institution, and in furthering its interests. In conjunction with Mr. Alex. Taylor he submitted a highly practical paper on "Boiler Furnaces," which was read and discussed before the Institution. He was one of the committee appointed to frame a general rule for the horse-power of marine engines on the basis of indicated horse-power, which rule was afterwards known as the Institution's rule for the normal indicated horse-power of marine engines and boilers. He died on the 24th of July, 1895, after a week's illness, from inflammation of the bowels, revered and regretted by many. In private life he had many friends, being a genial companion, was always ready to assist those in need, and contributed unobtrusively to several charitable undertakings.

CHARLES MITCHELL.

Charles Mitchell was born at Aberdeen, on May 22nd, 1820. After receiving his early education at a school in the Questrow, and at the Grammar School, he entered as a premium apprentice the engineering works of Messrs. W. Simpson & Co., predecessors of the firm of Messrs. Hall, Russell, & Co. He matriculated as a student at the Marischal College, and in 1840 was first prizeman in the chemistry class. In 1836 considerable additions were made to Messrs. Simpson's workshops, and he assisted Mr. John Coutts, an architectural draughtsman, in preparing the drawings, etc. Sometime previous to the completion of his apprenticeship in 1841, he gave drawing lessons in the evening to the late Mr. Andrew Leslie, who at that time was foreman boilermaker with Messrs. Bowman & Vernon, shipbuilders and engineers, and who afterwards became a shipbuilder at Hebburn-on-Tyne. On the completion of his apprenticeship he was employed as a draughtsman in the works of Mr. Coutts, who had left Aberdeen and had taken, in 1840, a building yard on the Tyne, previously used by Mr. William Reay for building wooden

vessels, and now forming part of Messrs. Wigham Richardson & Co.'s establishment. Here he commenced on the 24th September, 1842, the day after the launching of the paddle steamer "Prince Albert," which was the first iron steamer built on the Tyne. Two years later he obtained an engagement with Messrs. Maudslay, Sons, & Field, with whom he remained until 1852, when he commenced a shipyard at Walker-on-Tyne, upon a piece of ground which was then in process of being reclaimed from the river; and the yard was afterwards largely extended by the acquisition of other property. His first vessel, the "Havilah," was launched on February 17th, 1853, and is still afloat in Australia. In 1862, when the Russian Government determined to commence the construction of armour-clads in their own country, they entrusted his firm with the conversion of their wooden dockyards into iron shipbuilding establishments. He accordingly visited St. Petersburg, where he received an order for an ironclad, soon followed by others; and his brother-in-law, Mr. H. F. Swan, resided there for some years as the representative for the firm. In recognition of his services, the decoration of the Order of St. Stanislaus was conferred on him. In 1865, for the sake of health, he withdrew from the active part he had hitherto taken in business, and went to reside near London for a time. Subsequently, determining to return to Newcastle, he purchased, in 1869, the Jesmond Towers estate. His firm having been engaged for many years in building war vessels, in conjunction with that of Sir W. G. Armstrong & Co., an amalgamation took place in 1882, the name of the new firm being Sir W. G. Armstrong, Mitchell, & Co. The University of Aberdeen benefited largely by his generosity. In addition to aiding in the extension of the buildings, he gave a grand organ, and provided means to heighten the tower of Marischal College. In recognition of his munificent bequests, amounting to about £30,000, the Senate of the University conferred on him in February, 1893, the honorary degree of Doctor of Laws. His death occurred at his residence, Jesmond Towers, after a few days' illness, on 22nd August, 1895, at the age of seventy-five.

RALPH HART TWEDDELL.

Ralph Hart Tweddell was born on May 25th, 1843, at South Shields, where his father was a shipowner. With a view of entering the army, he was educated at Cheltenham College, devoting his time at first especially to classical studies, and subsequently to preparing himself for the Royal Military Academy at Woolwich. His strong

mechanical instincts, however, led to his being articled on leaving school to Messrs. R. & W. Hawthorn, of Newcastle-on-Tyne. In 1863, while serving his apprenticeship, he invented a hydraulic tube-fixer, which did good work. Two years later he designed a stationary hydraulic riveter, and thus commenced the development of the system of hydraulic tools with which his name is so intimately associated. On the completion of his apprenticeship at the age of twenty-two, he went to sea as an engineer. At that time steam pressures at sea were increasing and the difficulties of doing good work with the greater thicknesses of boiler plates required were beginning to be felt. It occurred to him, therefore, to apply hydraulic pressure for riveting; and his first machine made by and for Messrs. Thompson, Boyd, & Co., of Newcastle, did the work perfectly with a pressure of 1,500 lbs. per square inch, and at about one-seventh of the cost of hand work. One of the special features of this machine was the use of a small accumulator, of which the ram fell a considerable distance at each stroke of the riveter, with the result that the suddenly arrested fall of the accumulator weight caused a materially intensified pressure to be exerted at the end of the stroke. By this and other inventions he helped to render possible the increase of steam pressures from 40 lbs. to 200 lbs. per square inch, which with multiple expansion in engines has reduced coal consumption from 3½ lbs. to a little over 1 lb. per horse-power per hour. In 1871 he brought out a portable riveter, which constituted an important innovation, giving hydraulic machine tools a character of their own; and it was with this first portable tool that his uninterrupted connection with Messrs. Fielding & Platt, of Gloucester, was commenced. The machine proved highly efficient, and its manufacture was then regularly entered upon, various modifications and improvements being from time to time introduced. In 1872 he opened an office in Westminster, and contributed to the Institution of Mechanical Engineers a paper on the application of water pressure to shop tools and mechanical engineering work. In 1873 the portable hydraulic riveter was first used for bridge work by Mr. W. H. Panton on the bridge which carries Primrose Street over the Great Eastern Railway at Bishopsgate Street Station, London. The work was done quickly and silently, and the reputation of the machine for this work was thereby assured. By this plan many large bridges in India have been built by native labour, with a minimum of supervision. In 1876 the French Government having decided to prepare works at Toulon for the construction of the largest iron and steel warships determined to adopt a complete installation of hydraulic machine tools on

the recommendation of M. Marc Berrier-Fontaine, by whom a description of the whole was given at the Paris meeting of the Institution of Mechanical Engineers in 1878. In the application of this system to shipbuilding a great amount of time, labour, and cost was saved. For locomotive work the hydraulic riveter was first used by Mr. F. W. Webb at the Crewe Works of the London and North Western Railway; the Italian Government used it for riveting gun carriages, to prevent working due to the shock of firing; and the Gloucester Wagon Co., Messrs. P. & W. MacLellan, of Glasgow, and the Great Western Railway first used it for under-frames of wagons. In 1874 Mr. Tweddell contributed a second paper to the Institution of Mechanical Engineers on the application of water pressure to driving machinery and working shop tools, and in 1878 a third paper on the application of pressure-intensifying apparatus to hydraulic presses. He was a member of the Research Committee on Riveted Joints. The numerous awards bestowed on him in recognition of his inventions included that from the Centennial Exhibition in Philadelphia in 1876, and the Grand Prix in the machine tool class from the Paris Exhibition in 1878, and in 1885 the Society of Arts awarded to him a special gold medal under the Howard Trust. He joined the North-East Coast Institution in the beginning of 1885, and in the following year he contributed a paper on "The Application of Hydraulic Pressure to the Driving of Machines and the Transport of Materials in Works." Though resident in London he took considerable interest in the affairs of the Institution, and when present was always ready to give his opinions on the subjects under discussion. Mr. William Boyd, the first President of this Institution, was connected with the late Mr. Tweddell in the design of some of his later hydraulic tools as well as with the original fixed riveter made by Messrs. Thompson, Boyd, & Co.; and this acquaintance, begun in 1863, ripened into a close and intimate friendship, which continued unbroken up to the time of Mr. Tweddell's death, which took place suddenly at his residence, Meopham Court, near Gravesend, on 3rd September, 1895, at the age of fifty-two, from aneurism, resulting from a fall from his horse a few years previous.

EDMUND FREDERICK WAILES.

Edmund Frederick Wailes was a native of Newcastle-upon-Tyne. At the age of thirteen years he entered the shipyard of Messrs. Wigham Richardson & Co., Low Walker-on-Tyne, where he served an apprenticeship of five years, and for two years afterwards he held the position of

chief draughtsman. He then entered the employ of Messrs. Davison & Stokoe, shipbuilders, Sunderland, as assistant manager, with whom he remained for about three years. He then obtained the appointment of manager of the ship department of Messrs. the Wallsend Slipway and Engineering Company, Wallsend-on-Tyne, which appointment he held for a period of three and a half years, when he joined Messrs. Henry Bucknall & Sons, of London, as their superintendent, and remained with them for a period of eight and a half years. While in this capacity, he had a considerable and varied business experience, both at home and abroad, and made many friends, which eminently fitted him for his future career. On leaving them, in 1887, he commenced practice on his own account as a naval architect and marine surveyor, and was held in high esteem by the leading underwriters, which was proved by the difficult and intricate cases entrusted to his care, and the implicit confidence placed in his professional decisions. He was also senior partner in the firm of Messrs. Wailes, Dove, & Co., enamel and paint manufacturers, Newcastle-upon-Tyne, and conducted a successful business up to the time of his death, which took place after a short illness from malarial fever, on the 17th December, 1895, at the age of forty-five years. He was well known in shipping circles throughout the United Kingdom, the Continent, and America. He took considerable interest in the Institution, of which he became a member at its formation in November, 1884. In 1887 he delivered a a paper before the Institution on "Improvements in the Construction of Large Stern Frames, Rudders, and Keels;" in 1891 he delivered another on "Proposed Improvements in the Construction of the Bottoms of Ships and Steamers;" and in 1892 another on "The Careening of Ships and Steamers for the Purpose of Practically Testing their Stability." He was very popular amongst all with whom he was acquainted, being a most genial companion and given to hospitality, and always endeavouring to act up to his motto, "Celer atque fidelis."

JAMES LAING, JUN.

James Laing, Jun., began his apprenticeship in the Deptford Shipyard, Sunderland, in January, 1876, and remained there until the middle of the year 1878, when he went to Dumbarton to Messrs. Denny Brothers, and was with them for eighteen months; after which time he returned to Deptford Yard, and was actively engaged in the management of the business, both in the office and in the works, up to within six months of his death, which occurred on the 23rd of January, 1895,

at Bournemouth. During the last few years of his life he had very indifferent health, and was frequently absent from business in consequence of the same. He was a member of the Institution of Naval Architects, and of the North-East Coast Institution, and was for three years a member of Council of the latter.

MORRIS WEST RUTHVEN, JUN.

Morris West Ruthven, Jun., who for a number of years was well-known in shipbuilding and engineering circles on the North-East Coast of England, was the second son of Mr. M. W. Ruthven, of London, a gentleman whose name is inseparably connected with the hydraulic propeller, the Ruthven rudder, and several other proposed improvements in connection with engineering and shipbuilding. Mr. Ruthven, Jun., commenced his professional career in the works of Messrs. J. & W. Dudgeon on the Thames, and was afterwards employed on the staff of Sir Edward Reed at Westminster; coming north he received an appointment with Messrs. Wigham Richardson & Co., of Low Walker-on-Tyne, and for about fifteen years held the position of chief draughtsman in their shipyard. Subsequently he was engaged as naval architect and surveyor for the Tower Line of Steamers, and later in a similar capacity with Messrs. J. M. Lennard & Sons, shipowners, of Middlesbrough. Mr. Ruthven, Jun., was a skilful and accomplished draughtsman, possessed of strong artistic tastes, and gifted with a keen and correct eye for symmetry of form and outline. He died on the 9th of April, 1896, at the comparatively early age of forty-six years, deeply regretted by a large circle of friends, among whom on account of his genial qualities and readiness to help others he was very justly esteemed.

FRANCIS WILLIAM WILLCOX.

Francis William Willcox was born at Birmingham, on the 17th March, 1840, and was the youngest son of Dr. John Willcox of that town. He was educated at the Birmingham Grammar School, and developing considerable mechanical ability he was apprenticed in 1855 to Messrs. Robert Napier & Sons, shipbuilders and engineers, Glasgow, with whom he remained seven years, during the latter period of which he had charge of the steam trials of vessels engined by that firm, and often made voyages to sea in charge of the machinery. During his stay in Glasgow he attended Professor Rankine's lectures at the University, and became thoroughly conversant with the theory and mathematics of

engineering generally. He left Messrs. Napier & Sons, and was appointed assistant to the late Sir John Anderson, C.B., superintendent of machinery at H.M. Royal Arsenal, Woolwich, taking charge in that capacity of machinery at home and out stations, as well as of the steam vessels of the war department. In 1866 he joined the firm of Messrs. J. & G. Rennie, engineers and shipbuilders, London, as managing draughtsman and chief designer, going to Egypt for that firm in connection with the fitting of the Khedive's Company Fleet, with the then newly introduced compound engines. In 1870 he was appointed manager and designer to Messrs. T. R. Oswald & Co., Pallion, Sunderland, whom he left in 1872 to commence practice as consulting and superintending engineer and naval architect with his partner, Mr. Wawn. Conjointly with Mr. Wawn, he built up one of the largest consulting businesses in the North of England, carrying out work for Lloyd's, Underwriters', and numerous insurance clubs in various parts of the world, and also had the superintendence of a large fleet of steamers. He was also patentee of several mechanical devices, including steam and hydraulic steering gear, ventilators of shipholds, and an improved screw propeller, with which he was very successful, having fitted them to over 600 vessels in all parts of the kingdom and abroad. His death occurred at his residence in Sunderland, on the 30th April, 1896, after an illness of four days, in his fifty-sixth year. He became a member of this Institution at its inauguration in November, 1884, and was also a member of the Institution of Mechanical Engineers and the Institution of Engineers and Shipbuilders of Scotland.

WILLIAM HINDSON.

William Hindson served his apprenticeship at the firm of Sir W. G. Armstrong, Mitchell, & Co., Elswick Works, and remained with that firm until he was twenty-six years of age. He then obtained an appointment with Messrs. J. Abbot & Co., Limited, Park Works, Gateshead, and was with them for twenty and a half years, the last twelve years of which he was works manager. In 1893 he commenced business on his own account, taking over the existing portion of the once famous Messrs. Hawks, Crawshay, & Co.'s works at South Shore, Gateshead, and these he carried on until his death, which took place on July 7th, 1896.

APPENDIX.

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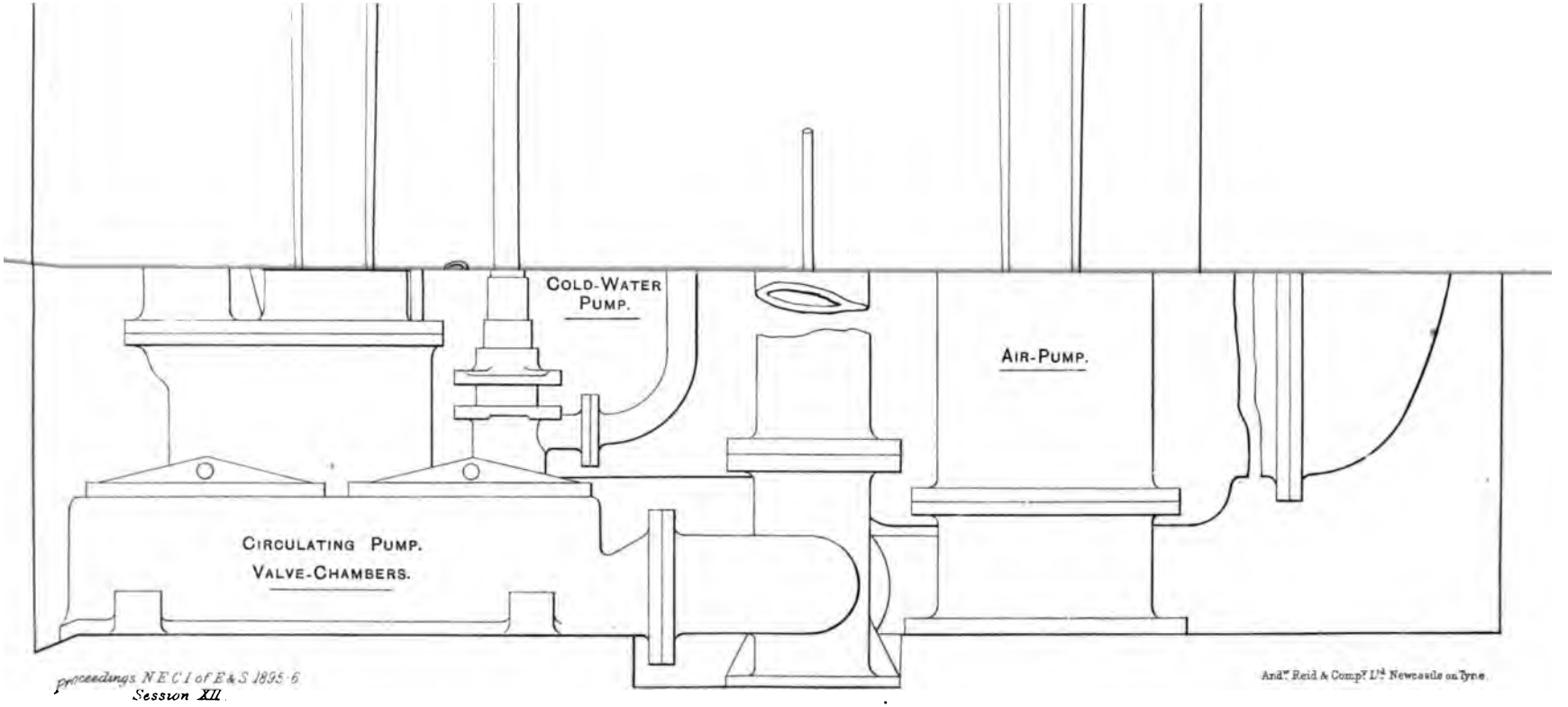

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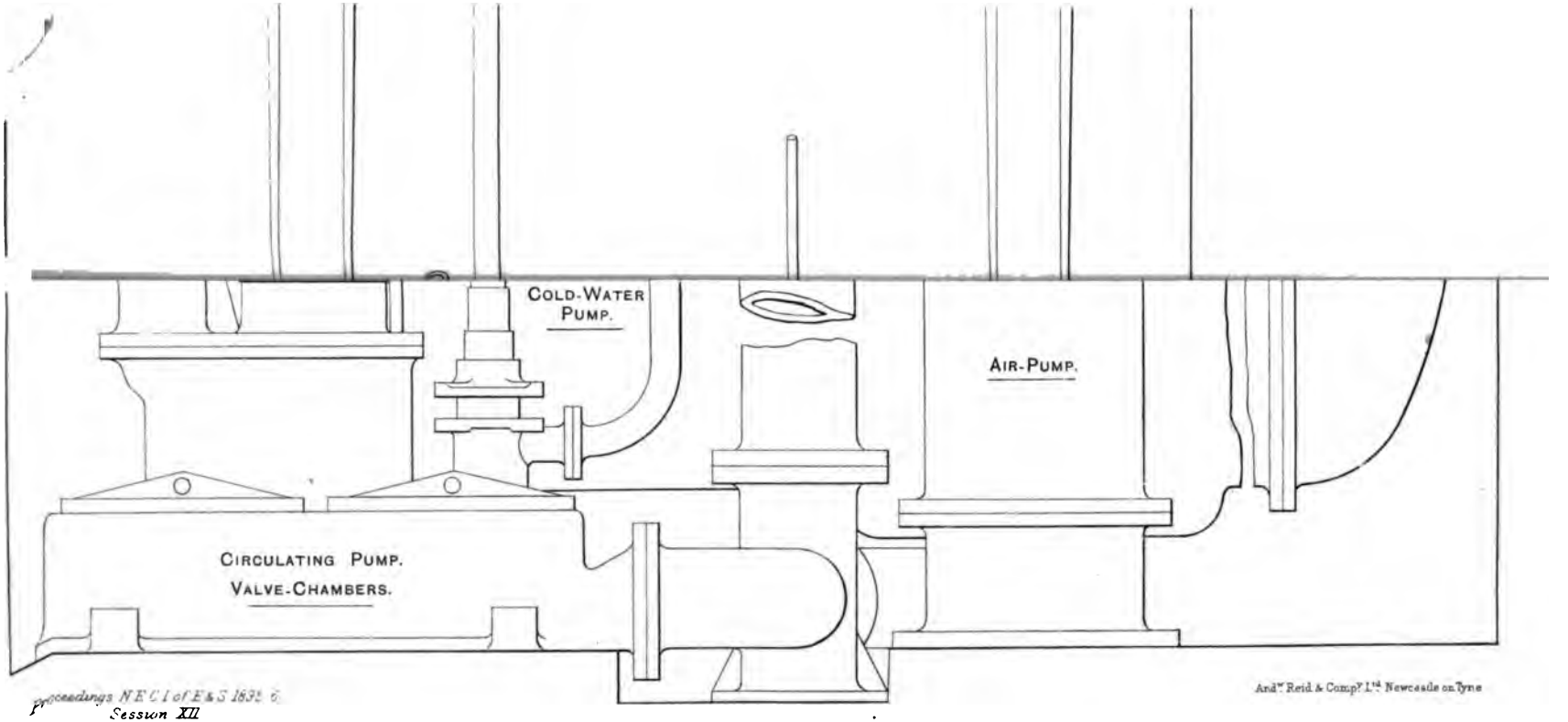

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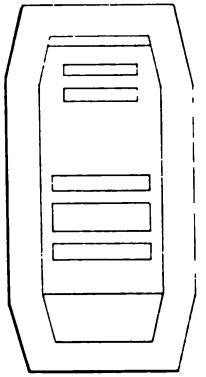

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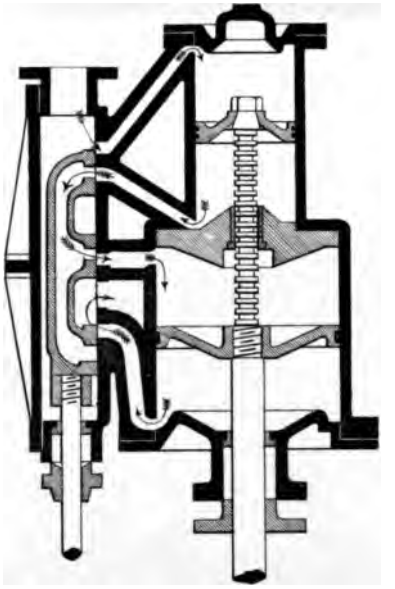

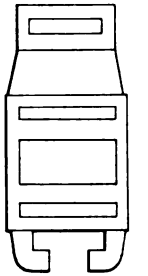

PLAN OF VALVE.

KINGDON'S CYLINDERS AND VALVE.

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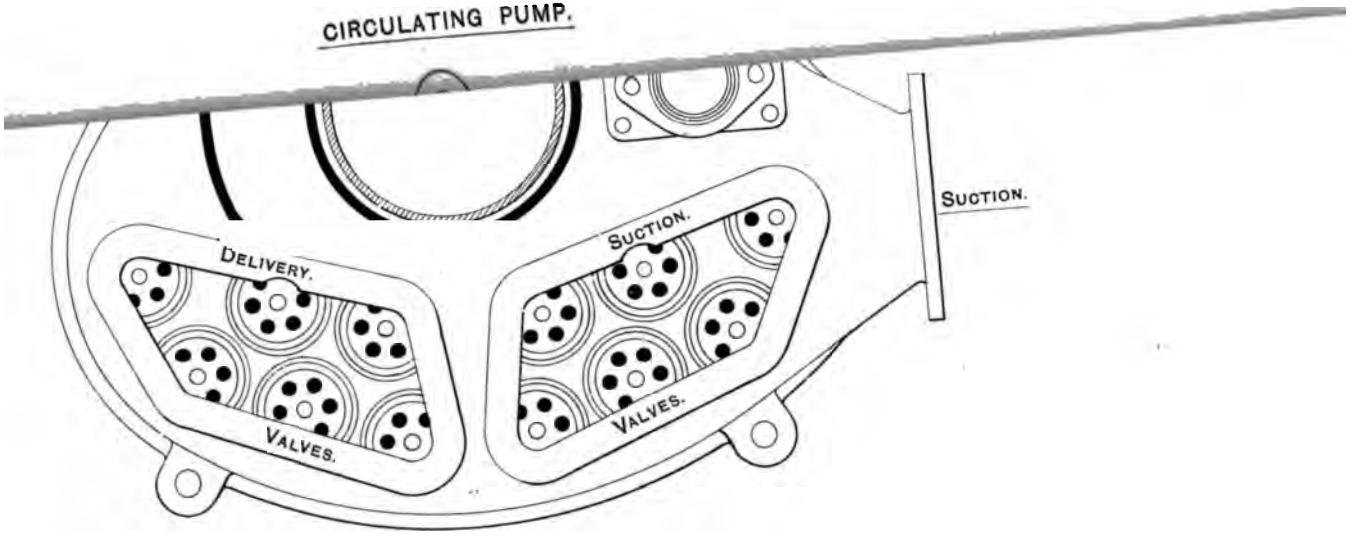
To illustrate Mr. W. Cross's Paper on "Surface Condensing Plant at the Newcastle & District Co's Electric Light Works."

FIG. 4.



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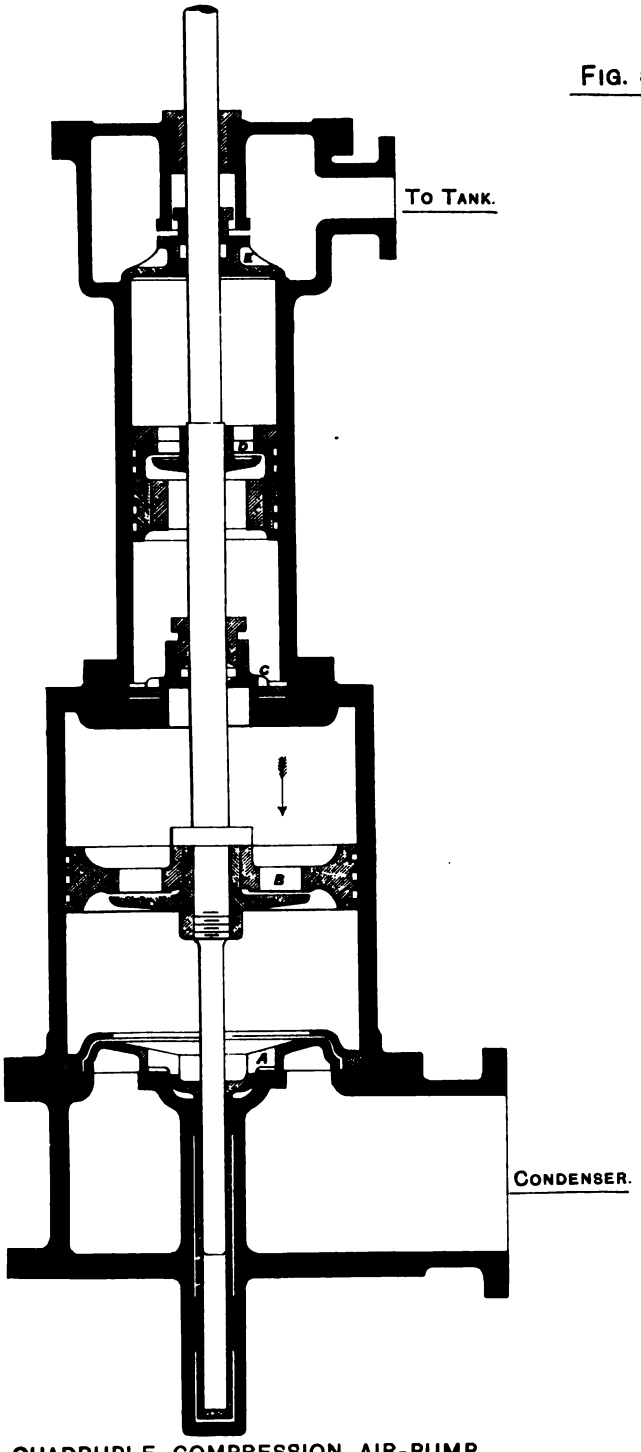
To illustrate Mr. W. Cross's Paper on "Surface Condensing Plant at the Newcastle & District Cos. Electric Light Works."

FIG. 5.



QUADRUPLE COMPRESSION AIR-PUMP.

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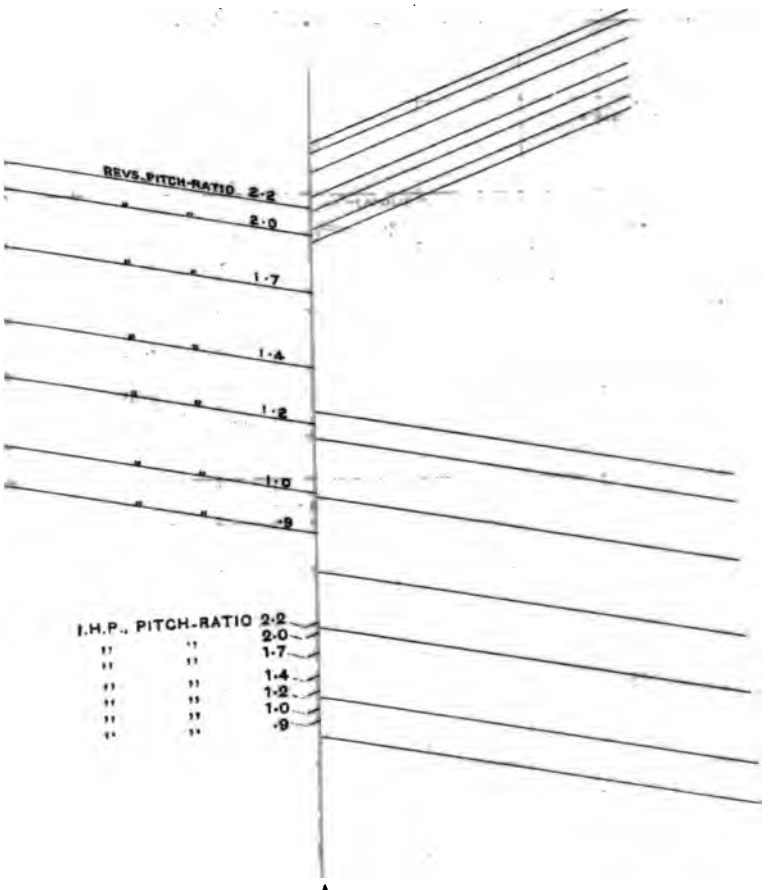

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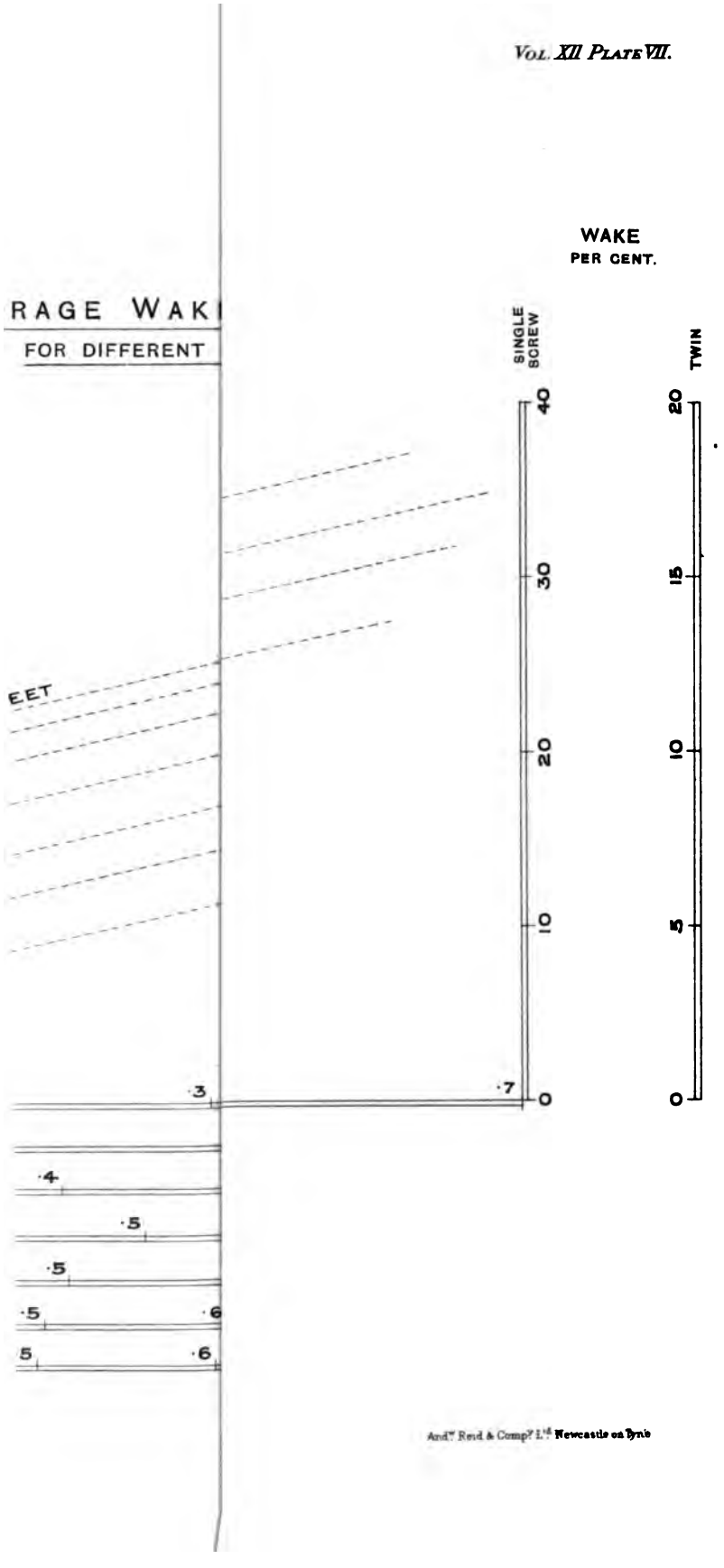

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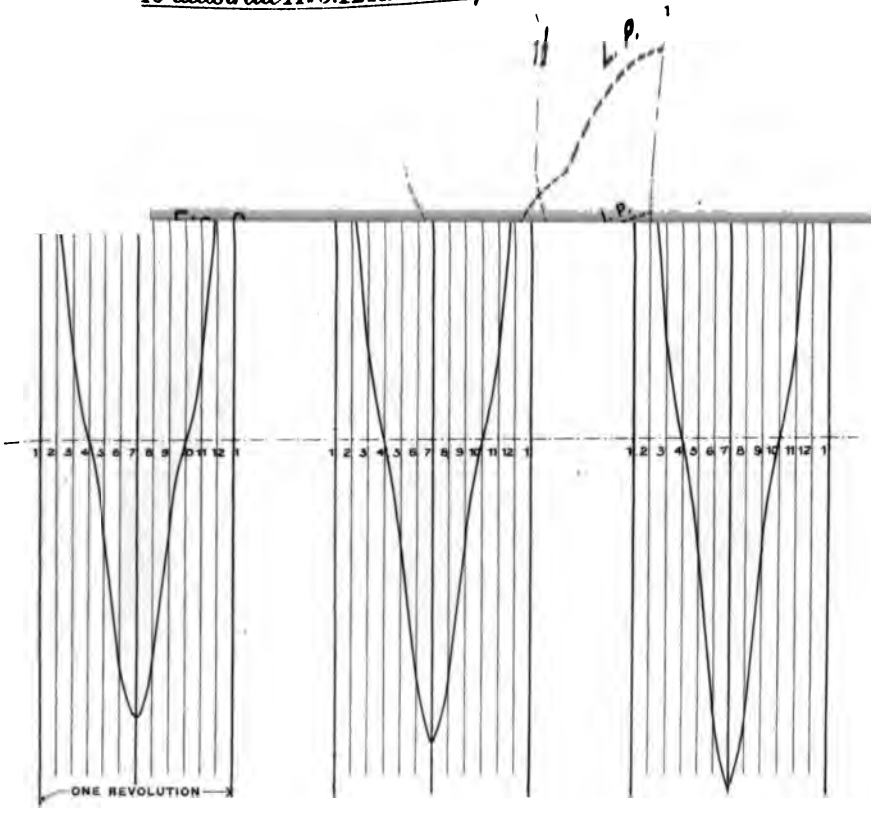
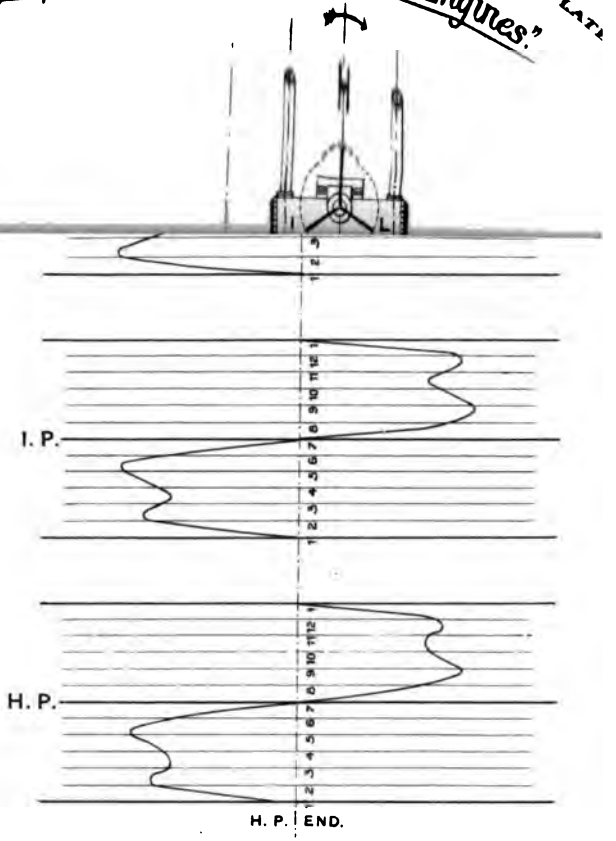


VERTICAL FORCES DUE TO INERTIA.
WITHOUT BALANCE WEIGHTS.



HORIZONTAL FORCES DUE TO INERTIA ONLY.
WITHOUT BALANCE WEIGHTS.

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Session XII

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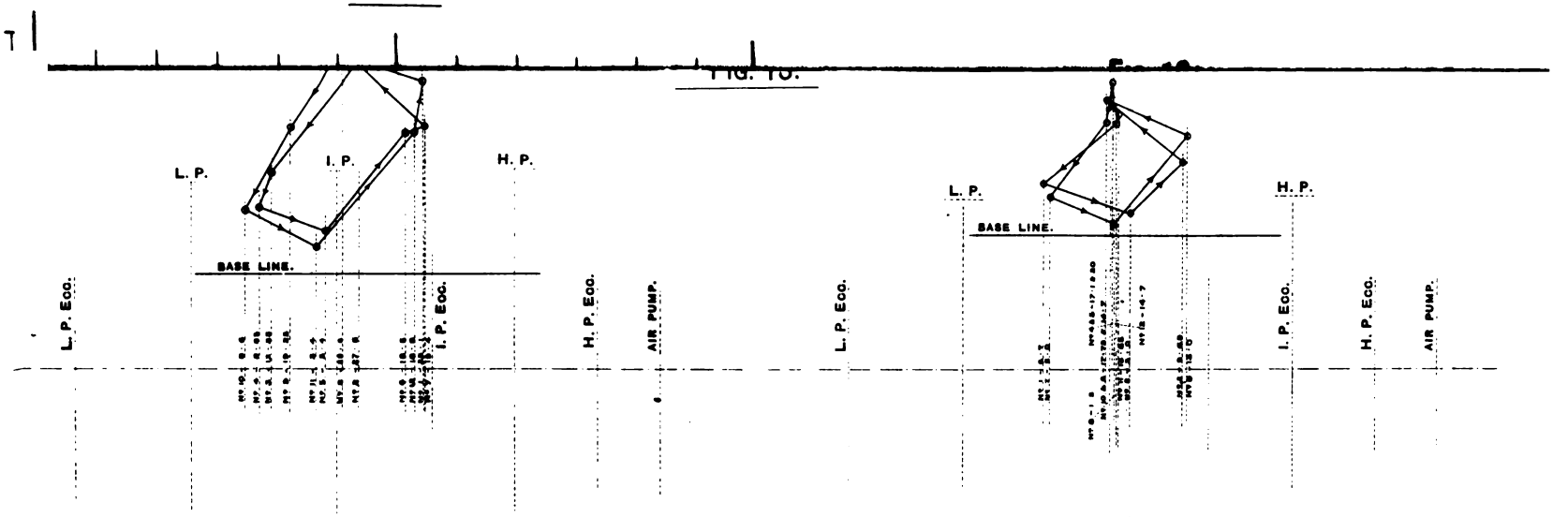
To illustrate Mr. R. Allan's Paper on "An Investigation into the Forces tending to produce Vibration in High Speed Engines."

FIG. 12.



MOMENTS IN A VERTICAL DIRECTION.

MOMENTS IN A HORIZONTAL DIRECTION.

DIAGRAM SHEWING POSITION OF AXES OF MOMENTS.
INERTIA ONLY. WITHOUT BALANCE WEIGHTS.

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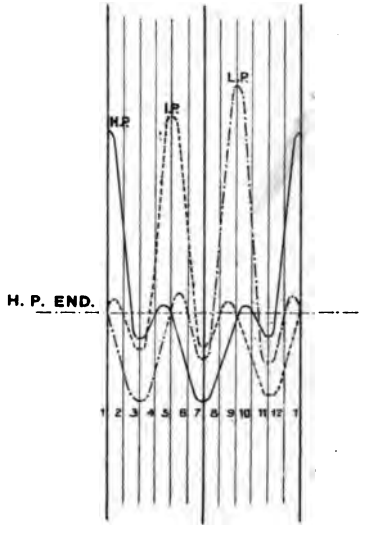
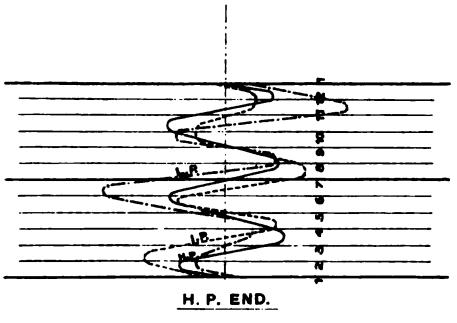


VERTICAL FORCES DUE TO INERTIA ONLY,
WITH BALANCE WEIGHTS.

FIG. 16.



HORIZONTAL FORCES DUE TO INERTIA ONLY,
WITH BALANCE WEIGHTS.

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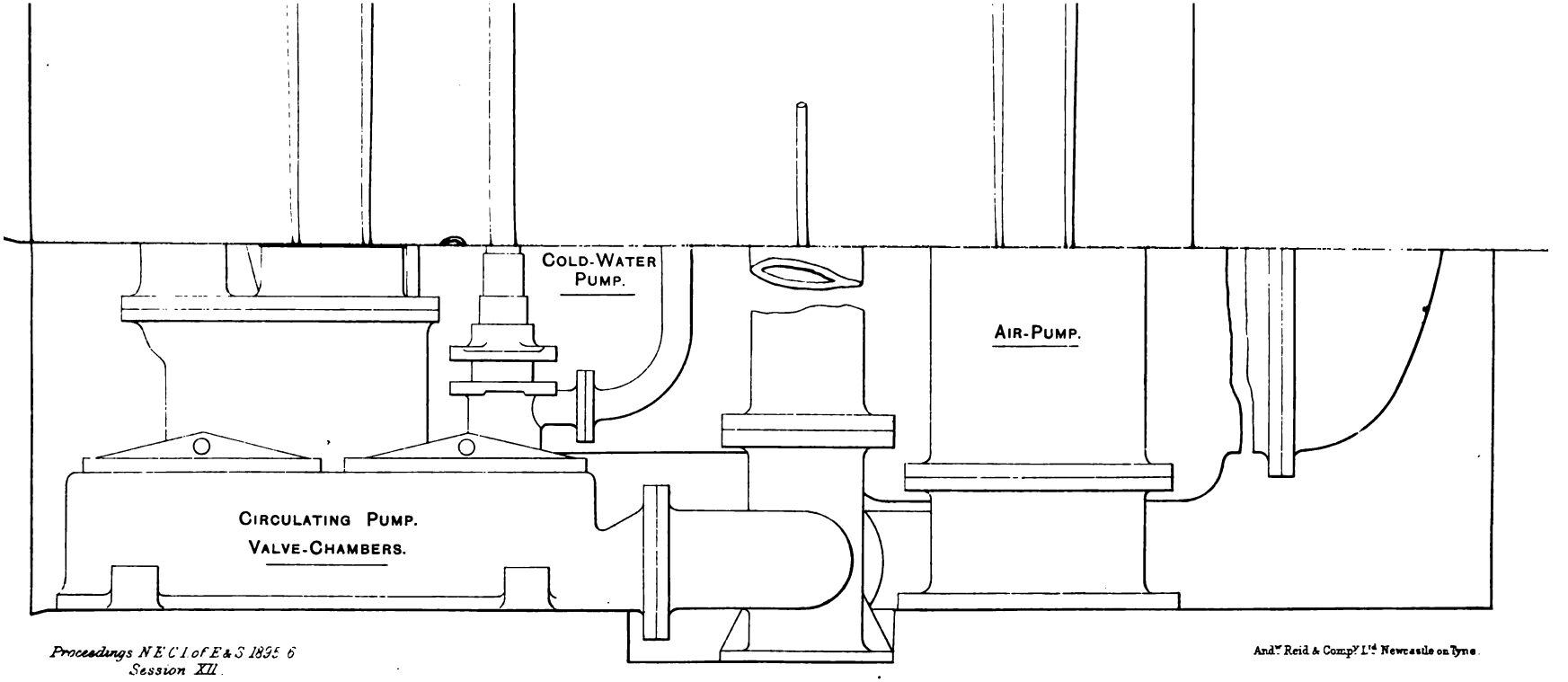

Proceedings N.E.C.I. of E. & S. 1895-6
Session XII.

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